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How to look for joint attention: Using a novel, multimodal coding protocol to identify joint attention in diverse parent-child dyads

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The Dissertation of Allison Paige Gabouer is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

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Abstract of the Dissertation

Parent-child interactions support the development of a wide range of socio-cognitive abilities in young children. As infants become increasingly mobile, the nature of these interactions change from person-oriented to object-oriented, with the latter relying on children's emerging ability to engage in joint attention. Joint attention is acknowledged to be a foundational ability in early child development, broadly speaking, yet its operationalization has varied substantially over the course of several decades of developmental research devoted to its characterization. Here, I outline two broad research perspectives—social and associative accounts—on what constitutes joint attention. After providing a theoretical overview, Chapter 2 introduces a joint attention coding scheme that we have developed iteratively based on a careful reading of the literature and our own coding experiences. This coding protocol provides objective guidelines for characterizing multimodal parent-child interactions. The need for such guidelines is acute given the widespread use of joint attention and other developmental measures to assess typically and atypically developing populations. In Chapter 3, we implement this novel protocol to understand how hearing parents are attempting to direct the attention of their deaf children, compared to those of hearing children. Contradictory to our predictions, both groups of parents relied on various multimodal cues to initiate joint attention with their child, regardless of the child's hearing status. We even found that hearing parents of deaf children incorporate auditory cues into their bids for joint attention, although parents of deaf children used shorter utterances in their initiation attempts compared to parents of hearing children. In combination, these results point to a seemingly consistent way parents initiate joint attention with their children, at least as these skills are developing and becoming more routine. Chapter 3 aims to extend these findings to dyads in which the children are older and have a more solidified grasp on engaging in joint attention. We documented several relationships between parent- and child-initiated joint attention strategies and their effectiveness, and found that parents and children rely on different senses to initiate joint attention successfully. Altogether, these studies emphasize the diversity in joint-attentional engagement across child hearing status and age, as well as the importance of tracking all types of sensory cues.

Chapter 1

Learning when and how to appropriately share attention is fundamental to social development and comes about so naturally that its emergence can be taken for granted. However, joint attention is a learned process developed over many months of behavioral interaction with others—the desire and willingness to share must be fostered through specific experiences. There are several theoretical perspectives on how joint attention emerges, each with notable differences in how this form of interaction is measured. Indeed, because exploration of the mechanisms underlying joint attention has been pursued by a wide array of research groups, its operationalization has diverged, resulting in a mixed bag of methodological approaches. Here, I use the term "joint attention" to refer to an active process in which two people focus attention jointly on a common object, with each person actively aware of the attentional status of the other. This definition contrasts with "shared attention," a term I use more generally to include interactions that do not meet the specifications of a socially-informed operationalization of joint attention. Forms of shared attention include coordinated gaze, point following, and other situations during which two people attend to the same thing.

Development of the ability to engage in joint attention lays the groundwork for many subsequent developmental advances. For example, evidence supports the relationship between joint attention and language learning (Mundy & Gomes, 1998; Salo et al., 2018; Tomasello & Farrar, 1986), consolidation of social cognition (Mundy & Gomes, 1998), increased visual attention to social partners (Striano & Stahl, 2005), increased pedagogical success (Mundy & Newell, 2007), and mastery of cultural conventions (Bruner, 1974). Given that human development relies enormously on shared experiences and knowledge (MacPherson & Moore, 2017), the fact that so many abilities can be related back to a child's early joint attention skills should not come as a surprise. Indeed, a child's ability to engage in joint attention is now recognized as a strong predictive indicator of typical development, social and otherwise.

This dissertation presents a series of studies in which I employ my own coding protocol, developed in response to differences in the methodologies presented by various research groups. I use this protocol to explore and outline parent-child interactions during different stages of development with an eye toward understanding when and how parents and children establish joint attention. Chapter 2 calls attention to the field-wide lack of consensus over the operationalization of joint attention and offers a coding protocol that can be utilized in observational work to better capture and describe these interactions. In Chapter 3, I present an initial iteration of the custom coding protocol our group developed to characterize how hearing parents engage in joint attention with deaf children and to differentiate it from how hearing parents do so with hearing children. Findings from this work have informed protocol enhancements and new questions, whose implementation is described in Chapter 4. In this final study, the refined coding protocol is used to assess patterns of joint attention between typically developing preschool-aged children and their parents while they read through a picture book.

Perspectives on Joint Attention

In their seminal study, Scaife and Bruner (1975) found that infants and young children engage in gaze following with adults, doing so as early as 6 months of age. An onslaught of research—and substantial debate—ensued, much of it focused on when different forms of attentional ability emerge in infancy and early childhood. At present, researchers' assumptions about how joint attention manifests across developmental time reflects their theoretical biases, as do their particular choice of terminology and how they operationalize what they're looking for behaviorally (Racine, 2013). Two generally distinguishable accounts have emerged, one that characterizes joint attention as fundamentally social, and the other that frames it as associative in nature (see Adamson et al., 2019 for an alternative framework). Both perspectives on joint attention are overviewed in this introduction, and a further breakdown of each is included in Chapter 2. The approach that has guided the work outlined here is very much from the social account. Despite this, findings from studies guided by the associative perspective have informed the research presented here as well.

Social Accounts

As with many complex behavioral constructs, precise operationalization of joint attention has come about gradually. According to the various social accounts, joint attention depends on a triadic interaction that relies on children's contingent interactions with caregivers (Striano & Stahl, 2005). Indeed, Bakeman and Adamson (1984) argued that coordinated joint attention is the most complex form of dyadic interaction there is between parents and young children (Bakeman & Adamson, 1984; Siposova & Carpenter, 2019). Thus, the social account is founded on the view that joint attention and its corresponding behavioral markers are grounded in social cognition. This operationalization translates behaviorally to a careful documentation of back-and-forth social interactions that require social awareness on the part of at least one member of the dyad, with achievement of joint attention also requiring some form of verification of attentional allocation.

Associative Accounts

The reasoning behind the associative perspective is that infants need not demonstrate interpersonal awareness to achieve a state of joint attention with another person (Corkum & Moore, 1998). Rather, on this view, joint attention is considered something largely dependent on infants' visual orienting system. Correspondingly, researchers whose theoretical perspective follows this vein argue that they do not need to appeal to any social processes (i.e., perspective taking, social referencing) to account for how such orienting might take place. This non-social perspective reflects ideas about how infants acquire and coordinate their own expectations of how adults behave physically around interesting objects, and thus does not require researchers to postulate any sort of psychological relationship between the adult, the infant, and the object of interest (Moore & Corkum, 1994).

Developmental Trajectory of Sharing Attention

Regardless of the perspective that guides the interpretation of research findings, it is clear that ontologically, the ability to share attention with others emerges early (~9 months; Mundy et al., 2007). Joint attention becomes a stable, common form of engagement by around age 2. Sharing attention can take many forms, the most advanced of which is joint attention (Bakeman & Adamson, 1984; Siposova & Carpenter, 2019). To partake in joint attention, one member of a dyad attempts to direct the attentional focus of the other, or makes a "bid" for joint attention. Going forward, I refer to an attempt by the initiator to direct another's attention to an object of interest via purposeful action as a bid. For example, if a mother and her infant are seated across a table and playing with several toys, the mom might pick up a small truck and say, "Look at this!" while holding the truck within the infant's visual field. These verbal and visual cues combine into the act of initiating joint attention. After the initiation act, the onus is on the infant to further engage, or respond to the bid for joint attention. The categorization of the response (i.e., successful or failed) refers to whether or not the infant directs attention toward the truck and her mother. While this particular example reflects the parent as the initiator, infants can also initiate joint attention.

Thus, joint attention is a reciprocal process made up of two component parts: initiating joint attention and responding to joint attention. More specifically, joint attention requires two people and one object of mutual interest. One member attempts to direct the attention of the other towards the object. Here, the member who is bidding for the other's attention is the initiating member, while the partner whose attention is being directed is the responding member—each initiator needs a potential responder. The initiation of joint attention focuses on the dyad member that is directing the attention of the other; responding to joint attention reflects the other member's willingness to engage. Critically, an infant's ability to initiate joint attention lags in developmental time relative to their ability to respond to joint attention.

Child Responding to Joint Attention

Joint attention emerges gradually as infants build on skills such as gaze following (Scaife & Bruner, 1975) and point following (Carpenter et al., 1998). There is evidence that 3-month-olds smile more when an adult alternates visual attention between the infant and an object, perhaps marking a precursor of responding to joint attention (Striano & Stahl, 2005). However, Scaife and Bruner (1975) found that it wasn't until around 10 months of age that infants were able to follow the direction of adult gaze reliably towards a visual stimulus outside their immediate field of view. It is only after they master gaze-following that infants begin to use the direction of adult gaze to effectively locate a specific target among distractors, an ability that emerges between 12 and 15 months (Butterworth, 1987; Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991). Similarly, other researchers (Lempers et al., 1977) have found that when the initiator's eyes and head are oriented in the same direction, only infants aged 12 months and older responded by orienting their gaze in the correct direction. Interestingly, infants as old as 19 months performed poorly when the orientation of the eyes and head were not perfectly aligned, suggesting that children are relying on more than just eye movement to guide their own attentional orientation well into the second year of life. Relatedly, haptic actions (e.g., toy manipulation) within the child's visual field also support efficient engagement in joint attention (Chen et al., 2020; Deak et al., 2014). Overall, there are many ways to initiate joint attention with young children.

Prior to initiating attention on their own, infants learn that caregivers and adults are intentional beings (Brinck, 2001; Woodward, 1998), and it is through these intentional interactions that infants learn others' pointing behavior is a communicative gesture. For example, parent pointing is associated with both infant pointing (Rowe & Goldin-Meadow, 2009; Tomasello et al., 2007) and infant language development (Salo et al., 2019). Once children can successfully follow the gaze cues of an adult, responding to joint attention appears almost reflexive.

Child Initiated Joint Attention

This willingness to follow the bids of others differs from the intention to engage with another person about an object or an event (Rothbart et al., 1994). To initiate an instance of joint attention, children must see themselves as intentional beings and be able to plan their own behavior. Rather, the initiation of joint attention is the use of one's own actions to direct the attention of others. Some researchers have argued that the initiation of joint attention on the part of a child marks the beginning of formalized intentional communication in humans (Brinck, 2001). Some researchers believe infants' earliest understanding of intentionality emerges around 9 months of age (e.g., Tomasello et al., 2005).

To participate in the directing of another's attention, the other person also has to be willing to follow the attempt. As early as 7 months, infants are sensitive to whether or not an adult successfully followed the infant's gaze, and they even prefer social partners who have previously followed their gaze relative to those who have not (Rayson et al., 2019). Gaffan and colleagues (2010) aimed to provide systematic documentation of infants' initiation of joint attention at 9 months. Researchers tracked how often infants bid for an adult's attention by animating the toy, offering the toy to the parent or experimenter, and extending a communicative point. Overall, they found that infants made very few bids for both parent and experimenter attention. There were so few such events, in fact, that for analytic purposes the researchers categorized infants simply as bid-making or not, thereby collapsing across different categories of bid types. Moreover, infants who made few to no bids for joint attention also had mothers who were more likely to show toys, tease with contact, and/or animate the toys (Gaffan et al., 2010), suggesting that perhaps these infants never initiated joint attention themselves because their mothers always did it for them.

Around 10 months, infants begin to use pointing in conjunction with gaze switching (Mundy & Newell, 2007) as they attempt to direct the adult's attention. Gaze switching elevates infants' pointing behavior from declarative to communicative as it reflects the desire to verify the adult's engagement. That is, an infant's willingness to check for the engagement of the adult suggests that their point was intentional and directed at the adult. This checking behavior is a crucial component of social accounts of joint attention. Following this point-and-look behavior, children will accompany the point with a word or sound around 14 months (Clark, 1978), thus marking their entry into the multimodal initiation of joint attention. This is followed by the fourth and final stage when, according to Clark, children produce utterances without incorporating a gesture. From between 15 and 17 months onward, children begin to take a leading role in the initiation of joint attention, thus easing the burden on parents to initiate (Heller & Rohlfing, 2017). These instances of joint attention, both infant- and parent-initiated, serve as foundations for several aspects of social development.

Correlates of Joint Attention

Language

A range of skills are linked to a child's ability to engage in joint attention, none more common than increased child vocabulary, both receptive and expressive. Indeed, joint attention (Delgado et al., 2002; Salo et al., 2018; Tomasello & Farrar, 1986), along with its antecedent components such as early gestures (Goodwyn et al., 2000; Salo et al., 2019), gaze and point following (Brooks & Meltzoff, 2008; Morales et al., 1998), sustained attention (Yu & Smith, 2016), perceived referential intent (Trueswell et al., 2016), and parental responsiveness (Tamis-LeMonda et al., 2014) have all been shown to predict subsequent language and vocabulary outcomes. Further investigation into this relationship has revealed individual differences in these skills that are not driven by biological age. Rather, the validity of the predictive relationship between joint attention and language relies on the particular amount of time spent in joint attention, as opposed to the child's age (Carpenter et al., 1998). Overall, the emergence of joint attention in young children provides opportunities for interactions that scaffold word-learning.

Social Cognition

Sharing a common frame of reference, followed by sharing of knowledge about said referent provides a scaffold for perspective taking. Frith and Frith (2007) defined joint attention as a means of sharing representations of the world by allocating attention away from an item of interest to one observed by another person. Therefore, joint attention opens a mutual exchange of information in which the individuals involved have the means to understand each other's intentions and goals. This ability to understand and resonate with the experience of another human also affords the sharing of feelings and emotions (Purves et al., 2008). Because joint attention relies on identifying an object of mutual interest, followed by the sharing of information related to the object, it creates an ideal environment to develop an understanding of the self and others. Most notably, early engagement in joint attention predicts later Theory-of-Mind abilities (Nelson et al., 2008), false-belief reasoning (Psouni et al., 2019), and use of mental state words (Brooks & Meltzoff, 2015). The increased ability to measure infants' cortical engagement using different neuroimaging methods is revealing that joint attention is supported by neural systems commonly implicated in social cognition more broadly (see Mundy, 2018 for a review). However, it is still unclear how the mechanisms supporting both joint attention and social reasoning are related and what this relationship means for the explanation of individual differences in these skills.

Typical and Atypical Development

Through the study of typically developing populations, we can attempt to explain the nuances of social learning and related processes. However, it is only when social cognition is interrupted that we realize the importance of these interactions. Moreover, it becomes apparent that we can better scaffold these learning experiences for some children. For example, a child's failure to engage in joint attention has recently emerged as an important indicator of possible developmental delay. One notable population in which joint attention and mature communication abilities can be delayed or absent is deaf children born into hearing families (Spencer, 2000). Atypical patterns of development can also reveal the breakdown in typical development and point to where the interruption has occurred and how it can be effectively repaired.

While there is relatively little research focused on communication in hearing parent-deaf child dyads, more is known about deaf parent-deaf child dyads. Deaf parent-deaf child dyads communicate using sign language and, because the parent and child share a dominant mode of communication, this dyad type is more comparable to hearing parent-hearing child dyads than to hearing parent-deaf child dyads. Lieberman and colleagues examined joint attention abilities and gaze shift patterns in deaf children while they took part in a joint book reading activity with their deaf mothers (Lieberman et al., 2014). These researchers found that deaf children of deaf parents exhibit unique and specific gaze patterns during communicative events relative to those observed in hearing children of hearing parents. It was evident that these children knew that the activity required multiple gaze switches in order to attend to both the visual stimulus of the book, and the visual language input. The parents elicited these gaze shifts by using a modality-specific prompt – physical touch or a gaze shift of their own. In another study, deaf parents were observed to scaffold their child's receptiveness to language by performing sign within the child's visual field (Nowakowski et al., 2009). These findings provide evidence that parents and children can change how they interact in an effort to accommodate the other member. Importantly, they also suggest that the emergence of joint attention is variable and provides an initial step in understanding how typically developing populations come to learn such interactions with ease. Relatedly, these findings can inform questions to help identify potential mechanisms that support either social or associative claims for engagement in joint attention.

Understanding the learning processes of typically developing populations also informs when and how these processes breakdown in atypical populations, and importantly can provide insight into achieving equipotentiality. In language learning, children must make connections between auditory information (words) and their referents. Of interest to many researchers is how children come to make the correct mappings of words and referents amid a chaotic stream of sensory information. Children with learning disabilities, like dyslexia, and other pervasive disorders, like ASD, struggle to perceive and combine multimodal cues (Stevenson et al., 2014). That said, these students especially can benefit from creative approaches to teaching and learning (see Birsh, 2005 for suggestions). With a better understanding of how multisensory cues are used to direct and engage in joint attention, we can better support children with atypical developmental patterns.

Identifying Open Questions

The studies presented here aim to explore and address several aspects of joint attention—from how it should be identified to how it is effectively achieved (or not). In Chapter 2, I review how joint attention is measured in parent-child interactions. Following this overview, I introduce the joint attention coding protocol created and used by our team, which we have developed iteratively and fine-tuned gradually. Our coding scheme provides objective, multimodal guidelines for characterizing parent-child interactions, including episodes in which joint attention is initiated as opposed to maintained. Importantly, our approach has already revealed that parents engage their children using an array of multimodal cues (Gabouer et al., 2018, 2020), knowledge that may better inform the development of therapeutic interventions and parent training techniques.

The emphasis on the visual modality in joint attention research has limited the questions that are deemed worthy of asking. By precisely characterizing the multimodal manner in which parents work to engage their children's attention from moment-to-moment, we can pursue a multitude of new questions about joint attention itself, including under which circumstances it emerges or is derailed. Based on a thorough review of the literature and our own experiences trying to apply various coding schemes to characterize parent-child interactions, we call for an open discussion about the need for consistent terminology and systematic operationalization in joint attention research. We provide specific directions for our coding scheme in the service of starting such a discussion.

Chapter 3 focuses on how joint attention occurs during semi-naturalistic parent-child play. Of specific interest in this study was how dyads in which both members have normal hearing differ from dyads in which the parent has normal hearing but the child is deaf. Importantly, nine out of every ten deaf infants born in the US are born to hearing families (Mitchell & Karchmer, 2004). In deaf child-hearing parent dyads, the child has limited-to-no access to the auditory modality while spoken language is the parents' primary modality for communication; the majority of children born deaf find themselves in this situation. Hearing parents of deaf children can attempt to learn and communicate with their child in sign language, and many do. But many more opt for their child to receive assistive technology, such as a cochlear implant, a device that bypasses the hair cells of the inner ear to directly stimulate the auditory nerve and thus providing the sensation of hearing (Yawn et al., 2015). However, there is limited information available to parents regarding how to communicate with their child during the pre-implant period whether or not they begin to learn sign language.

As more deaf children receive cochlear implants, researchers have begun to examine how parental interactions prior to implantation may affect the child's language development once they do receive their implant. In a study by Depowski and colleagues (2015), interactions in hearing parent-hearing child dyads were compared to those in hearing parent-deaf child dyads in which the child was a candidate for implantation. The researchers predicted that hearing parents of deaf children would work to engage their children using modalities (e.g., touch, vision) beyond the auditory domain (Depowski et al., 2015). Overall, results from this study showed that there was considerable variability in the type and amount of "multimodal communication" observed in hearing parent-deaf child dyads but that generally, hearing parents of deaf children worked to accommodate their children's unique communicative needs.

Chapter 3 presents research that builds on the previous findings by systematically examining patterns of modality use during joint attention episodes between hearing parents and their deaf children (all of whom were candidates for cochlear implantation) and compare these patterns to those observed in hearing parent-hearing child dyads. In this project, we focused on documenting instances of parent-initiated joint attention during a free-play interaction. Joint attention episodes were classified as either successful or not, and then were coded for the range of modalities used by the parents during those episodes.

The investigation of joint attention—both its antecedents and outcomes—is under-investigated beyond the age of three. Bean and Eigsti (2012), an exception, found that typically developing children, aged 7 to 17 years, exhibited variable proficiency in the ability to engage in joint attention. This findins suggests that the development of joint attention is not a uniform process for all children. These authors also point out the lack of age-appropriate assessments available to measure joint attention beyond these early ages. Thus, in Chapter 4, we explore several aspects of parent-child interactions to characterize how preschool-age children and their parents share attention. We do so by applying our previously generated protocol for identifying and describing joint attention to a task that is developmentally appropriate for preschoolers and their parents. What does typical engagement in joint attention look like at this age, and what could be producing these differences in joint attention?

Taken together, this collection of work provides a steppingstone toward a greater understanding of how parents and children interact naturally to engage in joint attention and what behaviors are most effective in these contexts to achieve it. Through this understanding, we can inform how parents and children can scaffold the achievement of this important attentional state in both typical and atypical populations.

Chapter 2

Introduction

Jean Piaget originally suggested that young children's egocentrism prevents them from considering the perspectives of others (Piaget, 1952, 1954). Decades later, Michael Scaife and Jerome Bruner expanded on then-current theories of infant egocentrism (e.g., Butterworth, 1987) by demonstrating that infants can use the direction of another's gaze to purposefully redirect their own gaze (Scaife & Bruner, 1975). Since then, efforts to identify the mechanisms that underlie attention sharing—*joint attention*—have bridged the social and perceptual aspects of the processing involved (Siposova & Carpenter, 2019; Stephenson et al., 2021). Here, we characterize two broad perspectives on what joint attention is, with the aim of identifying the key operationalization discrepancies that have contributed to confusion in the field. We then outline our own approach to coding joint attention, one that we have developed to flexibly accommodate different aspects of dyadic interactions, including those that vary by children's age and developmental status.

To partake in a shared experience, one member of a dyad attempts to direct the focus of the other. Although this shared focus of attention is now commonly referred to as joint attention, Bakeman and Adamson (1984) used the term "coordinated joint attention" in their seminal paper in which they documented the active coordination of attention between mother-infant and infant-peer dyads and an object of mutual interest. This form of shared attention is considered by many to be the most complex form of dyadic interaction between parents and young children (Bakeman & Adamson, 1984; Siposova & Carpenter, 2019). Several terms have since been used to describe the form of interaction in which a dyad shares attention to an object: joint visual attention (Butterworth & Jarrett, 1991; Scaife & Brunner, 1975), coordinated joint attention (Bakeman & Adamson, 1984), triadic attention (de Barbaro et al., 2016; Striano & Stahl, 2005), shared attention (Deák et al., 2017; Siposova & Carpenter, 2019), coordinated visual attention (Yu & Smith, 2017b) and coordinated attention (Chen et al., 2020), among others. At present, the most commonly used term, one that's become a catch-all for the concept of two individuals orienting together towards an object or event, is joint attention. The variable terminology and operationalization used by different researchers has resulted in confusion about what exactly constitutes joint attention, both within and outside of developmental research, as well as adjacent forms of attention (i.e., sustained attention). Clarifying the terminology is important because the term *joint attention* has come to have diagnostic implications. For example, as the underpinnings of Autism Spectrum Disorders (ASD) have come into focus, clinicians test abilities like joint attention to help identify children with ASD-specific deficits (Kasari et al., 2012).

Origins of 'Joint Attention'

At its inception, the sharing of attention, or "joint visual attention," was described and operationalized simply as gaze following. In their seminal study, Scaife and Bruner (1975) examined whether and how infants capitalize on the visual attention of an adult in order to locate an object in the immediate environment. These researchers observed that infants could successfully follow an adult's 45º head turn—in either direction—to search for the focus of the adult's interest. Years later, Roger Bakeman and Lauren Adamson (1984) began documenting the gradual developmental progression of infants' ability to

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coordinate their attention with the attention of others, whether caregivers or peers. In the service of clinical applications, as well as in support of a general interest in how the dyadic partner plays a role in child development, Bakeman and Adamson (1984) defined six states of child engagement, delineated based on free-play sessions during which 6- to 15-month-olds interacted with their mother or a peer. Engagement states ranged from completely unengaged to what the researchers then referred to as "coordinated joint attention," a state of engagement deemed to be the most advanced of the six. Coordinated joint attention was thus introduced to the field as the *active coordination of attention between two people in a dyad and the object one of the two people is focused on or involved with*. In other words, Bakeman and Adamson (1984) operationalized joint attention as the *active* coordination between two people about an object or event of interest.

One interpretation of this *active coordination* terminology is that it centers operationalization of joint attention on the social dimension of dyadic interaction, meaning that joint attention is not passively achieved. This perspective contrasts with a perspective that includes incidental engagement of attention, during which an infant might follow another's gaze without it being the intention of the gazer for his or her gaze to be followed. Indeed, active versus passive coordination between two people towards an object of interest proves to be a crucial distinguishing feature across the different accounts of joint attention, one that underscores disagreements over how joint attention supports infant learning, including language learning, more broadly. This subtle differentiation—between active and passive attention—is also the source of substantial confusion both within and outside of developmental research about what joint attention is (see Emery, 2000; Tomasello et al., 2005 for further discussion). While there would certainly be a benefit to some overall semantic agreement (i.e., differentiation of accounts based on the terminology used), our goal in this overview is not to be dictatorial about how the term "joint attention" is used. Rather, we aim to encourage researchers to be clear in what they mean when they call something joint attention—including how it is identified, the requirements for inclusion in that identification, and ideally consideration of how these requirements impact the research findings themselves.

Perspectives on Joint Attention

Social Account

The social account, as previously highlighted in chapter 1, asserts that the engagement in joint attention requires socio-cognitive reasoning, such as mentalizing and perspective taking (Mundy, 2018). In particular, Michael Tomasello has been a strong proponent of joint attention as an active process. In his seminal study on the relationship between joint attention and children's lexical development (Tomasello & Farrar, 1986), he introduced a set of objective guidelines to document joint attention in parent-child interactions. Critically, these criteria included an emphasis on identifying active coordination of understanding between two people. To this end, Tomasello and Farrar (1986) applied a novel coding scheme to parent-child free-play sessions, using a plus (+) and minus (-) system to identify episodes of joint attention. To qualify, an interaction had to contain (a) one member of a dyad initiating engagement with the other, (b) both members of the dyad focusing on the same object for three or more seconds, and (c) the member of the dyad that initiated the interaction showing clear evidence of awareness of the dyadic partner being successfully engaged (i.e., a verifying look towards the other). Only when an interaction received a plus for all three features did it meet the criteria for joint attention. These behaviors can be observed as they naturally unfold during a free-play interaction between a parent and child. They are in no way guided by the researchers themselves, who instruct parents to play with their child as they normally do. Thus, task demand is not an issue in how parents or children behave in these interactions.

One critique of the social approaches is that components of protocols built to capture these social accounts of joint attention rely on subjective assessments of the interaction as opposed to the objective, skill-based measures used in assessments prompted by associative accounts. However, concerns about subjectivity should not exclude the application of a more qualitative lens in assessing parent-child interactions; the solution is clear operationalization and a set of objectively based coding criteria. In fact, several implementations of naturalistic coding have been informed by objective measures of joint attention. We return to this point in Section 3, where we suggest ways of varying the timing and descriptive components of our coding protocol to fit the needs of the interaction being assessed and the developmental skill-level of the participants involved.

Associative Account

In contrast to the social account, some researchers use an associative account to explain joint attentional engagement. This perspective reduces the interaction to a geometric, orienting mechanism. In an example of this perspective, Butterworth and colleagues (Butterworth & Jarrett, 1991) defined joint attention as gaze following (i.e., as happens when a child looks where someone else is looking). Such a definition is inherently non-social, meaning that co-occurrence of gaze is the only criterion for the achievement of joint attention. Rather, these researchers proposed that joint attention is the product of a "geometric mechanism" that enables infants to attend to the same thing as another person, meaning there is no need to invoke any sort of mental-state reasoning— reasoning about the other—on the part of the infant. According to this geometric model, infants are able to use the direction of an adult's head-turn to infer the possibility of an interesting object in that direction. The logic goes that once the infant engages in a correct head-turn, the object is salient enough to attract the infant's attention (e.g., a light bright enough to be noticed). Thus, on this view, rather than being a social process, joint attention relies on an infant's sensitivity to geometric orientation of another's head-turn and on the attention-catching properties of the referent itself, with no need to postulate whether communicative intent underlies an initiator's behavior or not.

Critical to the points addressed in the subsequent chapters, associative accounts do not dictate that there be intentionality on the part of either member of a dyad for joint attention to occur. Thus, researchers who take this view do not include documentation of verification by one dyadic partner that the other's attentional allocation has been adequately directed to the object of interest (Butterworth & Cochran, 1980; Scaife & Bruner, 1975). Regardless of perspective, the terminology often used to refer to such verification ("checking back") couches identification of joint attention in the visual modality alone. On this view, other sensory information, whether provided by the infant, the dyadic partner, or by features of the object of mutual interest itself (e.g., rattling noise produced by parent shaking a toy) would not be included in coding of intentionality. It is noteworthy that this perspective has changed somewhat in recent years, as reflected by findings that highlight the impact of multimodal input on infant attentional allocation (Depowski et al., 2015; Suarez-Rivera et al., 2019).

One difficulty for associative accounts is the variability observed across parent-child dyads in so-called checking behaviors. This term is used by researchers (e.g., Baldwin, 1991) to refer to the quick look back by an initiator of joint attention towards the dyadic partner, arguably suggesting intentionality in their attempt to engage the other in joint attention. Where such behavior is taken by some researchers as evidence that the initiator is invested in the responsivity of the other dyadic partner to attempts at attentional engagement, a view that is consistent with the social account, others (i.e., Moore & Corkum, 1994) argue that such checking behavior is the result of the completion of an engagement episode, whereby the child's gaze returns to the adult's face with the goal of finding new cues about other visually-engaging referents. Interestingly, these accounts predict different outcomes in terms of who is doing the checking back. Whether or not the mechanism(s) underlying the checking-back behavior is grounded in any sort of mental state reasoning is itself a topic of debate.

The Present Approach

This overview should be taken as evidence that the nature of and basis for joint attention will continue to be the topic of debate for the foreseeable future. Rather than engage on it, we introduce our perspective here as a means of accounting for the decisions we have taken in our approach to coding protocol. The protocol is guided by the view that emergence of joint attention is attributable to experience-based advances in social cognition that drive infants' attentional allocation. These advances can include both endogenous factors, principally neurocognitive development itself (Mundy et al., 2003), and exogenous factors, such as explicit integration of experiences with goal-related behavior (Tomasello et al., 2005). In short, our perspective is that the foundation for engagement in joint attention is fundamentally socio-cognitive.

An integrated mechanism that many consider critical to the process of sharing attention was provided by Michael Posner and Mary Rothbart (2007), who identified a neural circuit for attention that includes a posterior attentional system responsible for representation, imitation, and perception in relation to others, and an anterior system responsible for intentional, goal-directed attentional focus. An important and still-outstanding question is how this attentional circuit emerges in the first place. One view from the clinical domain (Dube et al., 2004) is that consecutive behavioral processes early in development collectively build such that a child acquires the ability to shift interest between a toy and an adult in order to "share the experience" with that person. Such sharing of attention is considered a different class of behavior from gaze shifting.

Precursor behaviors are important in their own right. A recent proposal inspired by dynamic systems theory (Thelen & Smith, 1996) envisions individual growth in attentional skills as a fundamentally social process influenced by both intrinsic and evoked activity whose inputs collectively produce the variable outcomes in children's ability to regulate attention (Yu & Smith, 2016). Another recent proposal focuses on the underpinnings of shared attention, arguing that such states can occur either intentionally or incidentally, but necessarily result in an exchange of information about the environment and the mental states of the parties involved (Stephenson et al., 2021). Our own efforts focus on what happens in parent-child dyads as children become developmentally able to actively engage with objects together with other people, who themselves may adjust their behavior to better support children's attentional focus (Dube et al., 2004). Given this, we do not take a position on the origins of joint attention; however, our approach requires inclusion of attentional verification as a criterion for an interaction to qualify as joint attention. Critically, rather than rely on terminology that prioritizes vision over all other modalities, we adopt the position that any indicator (i.e., a look, a touch, a nod, a verbal affirmation) that the parent is attuned to the child's attentional allocation qualifies as verification.

Current Protocols for Assessing Joint Attention

Several protocols are available to guide assessment of children's engagement in joint attention. Many of these involve an experimenter actively engaged with the child, whose interaction is coded in real-time or post-hoc to characterize children's unprompted interaction with a caregiver in anywhere from a natural to a semi-structured environment. A widely used protocol in the clinical domain is the Early Social Communication Scales (ESCS; Mundy et al., 1996), a structured observation scored in real time by a trained experimenter. The ESCS elicits three specific, quantifiable social-communicative behaviors: joint attention behaviors, requesting behaviors, and social interaction behaviors, while using eight different tasks to assess the target behaviors, including turn-taking, gaze following, book reading, and requesting. Children are scored based on their portrayal of low- and high-level behaviors, where high level behaviors and correct responses result in higher scores. Overall scores are used to produce a social communication profile for the child.

Researchers have also developed protocols to identify and describe engagement in joint attention from the perspective of an onlooker. In these instances, dyads engage in a free-play session with an adult, uninterrupted by prompting or technology. These interactions are typically recorded and coded offline, incorporating specific criteria for characterizing different components of the interaction, including bouts of joint attention (Bakeman & Adamson, 1984; de Barbaro et al., 2016; Nowakowski et al., 2009; Salo et al., 2018; Tomasello & Farrar, 1986). The different protocols consist of components intended to provide guidance on codable criteria, with agreement between coders assessed via interrater reliability. Not surprisingly given all the issues we have outlined here, these coding protocols can differ substantially on what constitutes joint attention, underscoring the need to better characterize the action of interest rather than simply labeling it. In our efforts to generate a protocol that supports the most objective coding possible, we have found that the various approaches each provides important and unique insights.

Although we focus on video-based manual coding here, we would be remiss if we did not acknowledge the impact that technological advances (i.e., head-mounted eye-tracking) have had on the field by allowing increasingly precise documentation of the focus of dyadic partners' gaze throughout the course of an interaction. Many researchers are now using eye-tracking to establish the statistical properties of the interactions. Because eye-tracking data can be parsed in various ways using machine-based coding, researchers are not only able to identify overlaps in visual gaze, but also relate one or both participants' looking behavior to other events. For example, overlaps between parent and child gaze has been shown to be predictive of vocabulary development (Abney et al., 2017), to relate to hand-eye coordination (Yu & Smith, 2017a) and result from what children see their parents touch (Deak et al., 2014). Additionally, eye-tracking patterns are being used to inform changes in parent behavior that can improve joint attention and child learning during dyadic reading activities (Guo & Feng, 2013). We have also benefited from the insights that these approaches provide, particularly around issues having to do with the application of time windows for classifying different behaviors.

Development of Coding Protocol

Here we introduce a coding protocol that integrates components of the different approaches to joint attention that we have outlined. In particular, the protocol is inspired by the work of Tomasello and Farrer (1986) and of Nowakowski and colleagues (2009), with timing details founded on insights from both visual observation (Bakeman & Adamson, 1984) and eye-tracking (Abney et al., 2017; Yu & Smith, 2013). Critically, our approach allows coding of both the *initiation* of joint attention (by both/either parent and child), and *maintenance* of joint attention (again, by both members of the dyad). We have found that it is critical to distinguish between the initiation and maintenance of joint attention to accurately characterize the interaction from moment-to-moment. Another important aspect of our approach is that we incorporate the potential to identify the range of sensory cues produced across different modalities by both members of a dyad, which can be tracked alone and in combination. We have added the multimodality dimension of our coding in light of findings from both social (Baron-Cohen, 1991) and associative (Moore & Corkum, 1994) accounts. More recently, our approach is proving to be consistent with results obtained using eye-tracking (Yu & Smith, 2017b), as well as those from observational coding (de Barbaro et al., 2016), whose findings that infants are particularly responsive to their dyadic partners' hands is something we documented early on in our own coding (Bortfeld & Oghalai, 2020; Depowski et al., 2015; Gabouer et al., 2018, 2020). Starting with our initial observation of the importance of the caregiver's hands (Depowski et al., 2015), we have iteratively fine-tuned our protocol with each data set to better characterize this phenomenon.

Basis for coding protocol

Our joint attention coding criteria are based on active engagement with hundreds of hours of parent-child interaction videos (Bortfeld & Oghalai, 2020; Depowski et al., 2015; Gabouer et al., 2018, 2020), as well as careful reading of others' research. Our focus has been on how to characterize the factors that lead to joint attention and to do so systematically, with an eye towards establishing a mechanistic account of this phenomenon. Our interest originated in efforts to establish guidelines to support joint attention development in children who are deaf or hard-of-hearing and who do not have access to consistent sign language input, a situation that is quite common among deaf children of hearing parents who are candidates for cochlear implantation but have yet to be implanted. These are among the children for whom the establishment of joint attention can provide a critical scaffold to learning about communicative intent prior to their exposure to consistent, structured language input.

The guiding question behind our approach has been whether and how hearing parents can establish joint attention with their deaf children when the typical manner by which this is achieved is (i.e., parental vocalization) is not available to the children. It was in pursuit of answers to this question that we characterized parental behaviors that lead to joint attention in hearing parent-deaf child dyads as well, to compare with behaviors in hearing parent-hearing child dyads. While trying to apply others' coding guidelines to our own parent-child interaction videos, it became clear that we needed to develop a step-by-step guide for identifying how the two components of joint attention—initiation and maintenance—proceed for both members of a dyad. Moreover, as we developed and applied our own increasingly stringent coding criteria, it was clear that members of our control dyads (i.e., hearing parents of hearing children) were doing things to achieve and maintain joint attention with their children that had not been mentioned in any of the joint attention research reports we were reading.

Originally, we predicted that hearing parents would rely on auditory cues to initiate joint attention with their children, regardless of the children's hearing status, due to their personal familiarity and comfort operating in the auditory modality. We also expected that hearing parents of deaf children would achieve less child engagement in joint attention overall, due to the child's hearing status and the parent's inability to sign. Quite to the contrary, however, we observed that hearing parents, whether of deaf or hearing children, were equally effective in establishing joint attention with their children, and that they did so using a range of different cuing techniques that spanned multiple modalities.

We have now finalized a revised set of criteria (see Figure 1). First, an initiating partner attempts to direct the other person's attention to a nearby object or shared experience. This initiation can happen through a variety of sensory cues—auditory, visual, or tactile—as well as any combination of the three. These actions must by purposeful and intentional, conveying an overt attempt to engage. Following the initial action from the initiating partner, the non-initiating partner must jointly attend to the object of mutual interest. This "following in" to the initiation cue can also be accomplished through multiple actions such as a gaze-shift, acting on the object, or engaging in verbal conversation regarding the object. The third feature—demonstration of awareness— is done by the initiating partner as a way to ensure the non-initiating partner has noticed their initiation attempt and effectively integrated into the triadic interaction. We have found that researchers often discount this checking behavior, characterizing it as something that happens outside of the joint attention interaction. This oversight is likely the result of the theoretical disagreement over what joint attention is as opposed how the interaction itself unfolds.

Implementation of coding protocol

In previous sections, we identified sources of disagreement about what is an is not necessary for a dyad to be considered as engaged in joint attention. Indeed, we now recognize that the terminology different researchers use to characterize different attentional states, including joint attention itself, is highly variable and often contradictory. Consistent with our intuitions, a recent paper (Siposova & Carpenter, 2019) calls attention to this problem and attempts to characterize various states of attention in dyadic interactions in light of different degrees of common knowledge between dyadic partners. Thus, there is a critical need for an open-ended discussion about discrepancies—both theoretical and mechanistic—in joint attention research. To this end, we share our systematic coding approach. Our micro-coding scheme is grounded in the following definition of joint attention: the active and intentional engagement between two people regarding an object of mutual interest. In outlining our approach, we address discrepancies that we have identified in others' approaches and provide reasoned resolutions that can be objectively applied in future research.

Proposed Coding Scheme

Our scheme consists of three component steps that involve identifying an attempt at initiation of joint attention and determining whether the attempt was successful or failed. Here, we use the term "bid" to describe such attempts, which are purposeful actions on the part of the initiator with the intent of directing the target's attention to an object of interest. Each step of the identification process is represented in a decision tree (see Figure 1). Although our previous work specifically focused on parent-initiated joint attention, the coding scheme can be used to identify instances of both parent- and child-initiated joint attention (see Section 3 for suggestions about how to use the protocol).

Intention

The initial step in identifying joint attention is determining whether a bid has taken place or not. The bid must be intentional and non-random, where intention is defined as events which the coders perceived as non-accidental and which the initiator acted purposefully to share attention with the target. Intention was largely gauged using the following indicators: (a) ostensive visual focus on the object of interest, (b) physical orientation toward the object of interest, (c) haptic interaction with the object of interest, or (d) an overt gesture toward the object of interest (Trueswell et al., 2016). Specifically, accidental actions (e.g., sneezing, grazing, tripping over a toy, etc.) are not motivated by intention to engage in joint attention, and thus do not meet the standard of a bid in the current coding protocol. Perceived intention additionally hinges on a third piece of criteria presented in the decision tree – active verification. Active verification is required on the part of initiator as it indicates concern as to the outcome of the bid, suggesting an intentional nature.

The requirement for a bid to be intentional is in contrast to most research conducted using eye-tracking in which data are classified via machine learning techniques (Guo & Feng, 2013; Yu & Smith, 2017b). These approaches generally include all instances in which the parent and child both attend visually to the same object, whether intentionally or not. Yu, Smith, and colleagues have demonstrated that these instances of coordinated looking are important for predicting vocabulary development (Abney et al., 2017) and the engagement in sustained attention (Suarez-Rivera et al., 2019), among other things. We acknowledge that learning can occur in these non-intentional situations (see Yu & Smith, 2013), but the lack of a verification component in these approaches contrasts with the "coordinated joint attention" described originally by Bakeman and Adamson (1984). The implications of these intentional episodes, in contrast to incidental engagement, is an open question that is worthy of investigation. We return to this point in the discussion regarding additional applications for the outlined protocol.

To engage in joint attention, one member of the dyad must have the intention to share attention with the other. Thus, intention is the first step in Tomasello and Farrar's coding (1984), a critical component of Racine's (2013) definition of joint attention, and the first decision in our proposed coding scheme (see Figure 1). Without intention, joint attention can happen by accident or just through coincidence when members of a dyad happen to focus their gaze or place their hands on the same thing at the same time. Without intention, what is being called joint attention is really just the result of happenstance, rendering what leads to it no longer interesting. In our approach, we emphasize the following question: How do parents direct their child's attention in a purposeful way?

Response Types

Engaged Response

Our two main criteria for characterizing the response to a bid are the type and duration of the response (see Figure 2). To this end, we employ three different rules of engagement. The first is as follows. Once the initiator has finished an initial bid for attention, the target has a five second window of time in which to respond (Figure 2, yellow bar; Bakeman & Adamson, 1984; Carpenter et al., 1998; Tomasello & Farrar, 1986), thus resulting in a successful bid. There are various actions the target can perform that we consider indicative of a successful bid. The non-initiating, or target, member can respond to a bid by pointing, gaze following, tapping, or touching the initiator, engaging with the object of mutual interest, deliberately gesturing within the initiator's visual field, changing affective demeanor, and/or producing language. The application of the three-second rule requires the target engage in one or several of the above responses for at least three seconds within five seconds (Nowakowski et al., 2009; Figure 2, yellow bar). Once a target has done this—a process often referred to as "integrating" with an object and dyadic partner—the target can fluctuate between various states of engagement or disengagement (Figure 2, green bar; Abney et al., 2017), provided that any disengagement does not exceed five seconds. The third timing component focuses on the timing for the initiator to actively acknowledge the engagement state of the target (Figure 2, blue bar). The current protocol employs a five-second window of opportunity starting from the time the target responds to the bid.

Failed Bids

We have yet to find any research on what characterizes bids that do *not* result in successful engagement in joint attention (Figure 1). In an effort to differentiate and compare successful versus failed attempts to establish joint attention, the proposed coding scheme provides the option to include codes for failed bids. Here, a failed bid is any intentional bid that does not result in successful engagement on the part of the target. Using the five-second response window (Figure 2, yellow bar), we can identify successful bids, as described above, as well as failed bids. When a target fails to attend/integrate with the dyadic partner within the three second window, this qualifies the initiator's bid as unsuccessful. For example, a parent may use gaze as a bid to initiate joint attention with a child. Often a parent will follow such a bid with labeling. However, if the child is preoccupied directing their gaze in another direction or engaging with a different object, the child may miss this visual bid. Likewise, a parent may be consistent in cue timing, but the cues themselves may not work to guide the child's attention. If a parent is insensitive to this fact, the opportunity will be missed for the parent to adapt bid strategies and thus accommodate a child's specific sensitivities. We realize this perspective may be controversial, but this highlights how critical it is to agree on the importance of the verification behavior in joint attention. We encourage researchers to use this coding scheme to investigate which intentional actions result in successful and failed bids, how one can "repair" a failed bid, and what role failed bids play in the long-term progression of dyadic interactions. We also encourage investigation into the prevalence and impact of verification behaviors more generally.

Active Verification

As we have argued, in cases in which a target is receptive to an initiator's bid, the initiator must confirm the target's focus of attention by showing some form of verification of the change attentional allocation (Tomasello & Farrar, 1986; Carpenter et al., 1998). Because dyads use several sensory modalities during interactions, several behavioral responses on the part of the initiator can qualify as verification. For example, a visual gaze change to the target to gauge reception to the initiation act, a vocalization from the target that is heard and responded to by initiator, or a manual/ tactile action that is seen or felt by the initiator (i.e., a visual gaze change to the target's hand). Such *active coordination* between the dyad and with object or event is the essence of social interaction and is quite distinct from so-called coordinated looking to the same object, which may or may not be intentionally engaged. Utilizing eye-track technology, Guo and Feng (2013) measured joint attention as a dyad engaged in a story book reading task. Their results suggest that by providing a critical piece of information, the direction of gaze of the dyadic partner, we can facilitate the regulation of joint attention and improve children's learning of print words (Guo & Feng, 2013).

In other words, verification provides a clear indicator that the bid was intentional. Ours is not the first joint attention protocol to employ a verification component. For example, Bayliss and colleagues (2013) referred to return-to-face saccades, in which one partner reorients to the other when sharing attention. These researchers characterized this as a form of social feedback that the initiator of joint attention uses to verify the outcome of his or her behavior. The requirement of such verification is also documented in research with children who are deaf or hard-of-hearing (Nowakowski et al., 2009; Prezbindowski et al., 1998). Finally, Striano and Stahl (2005) argued that previous assessments of joint attention were lacking the "monitoring component" (their term for verification of a bid's success or failure).

This criterion is relevant to both the parent and the child as initiator too. A view that is consistent with other domains of research, such as that employing the Still-Face Paradigm (Cohn & Tronick, 1983), in which infants demonstrate themselves to be sensitive to relevant social cues in a triadic interaction. Even very young infants (between 3 and 9 months of age) will spend a significant amount of time looking toward an adult when the adult coordinates both her affect and attention between the infant and an object, as opposed to simply coordinating affect or attention only with the infant (Striano & Stahl, 2005). Specifically, this pattern of gaze behavior (actively switching between the infant and the object of mutual interest) on the part of the adult results in the infant spending more time looking toward the adult. Overall, this suggests infants' exceptional sensitivity to relevant socio-communicative acts performed by the parent. Interestingly, these researchers (Striano & Stahl, 2005) suggested that converging, multimodal cues may also influence the engagement in joint attention, a view that has guided the focus of our own research (Bortfeld & Oghalai, 2020; Depowski et al., 2015; Gabouer et al., 2018, 2020), and is a topic that we will return to below.

Overall, we view joint attention through a socio-cognitive lens. In that spirit, we consider the initiator's confirmation of a target's reaction to an object a critical component of joint attention. For example, parents' use this reaction in deciding how to further the interaction to support learning; this checking behavior highlights the active and triadic dimensions of joint attention, in which monitoring of the infant's psychological relation to the object is critical (Campos & Stenberg, 1981). Without this acknowledgment, it is difficult to determine the intentionality of bids in the first place. This prompts a different yet related question regarding the implications of the initiator's sensitivity to the bid's success or failure. Currently, there is little evidence regarding such measures of sensitivity.

Not Coded

Given the restrictions we have outlined, there are interactions that are not coded as bids for joint attention, which may seem very intentional in all other respects. If an initiator does not verify engagement, we do not code it as a bid (neither successful nor failed) for initiation of joint attention. This category differs from the failed bid categories in that a failed bid is the result of the lack of the target's integration but does include checking-back. If the initiator fails to ensure that the target followed the bid and is also attending to the new object, then the bid is not coded, regardless of the target's behavior. Future research will need to pursue a means of comparing outcomes of non-coded instances with coded instances, as it is an open question whether they influence children's communicative development in a manner similar to those that are verified.

Tracking Multimodal Cues

In an effort to further characterize successful and failed bids for joint attention, we also examine how different sensory modalities are used in these attempts, both alone and in various combinations (i.e., Depowski et al., 2015). By coding and quantifying an initiator's use of multimodal cues, we can further inform a social account of joint attention and move away from a strictly visual interpretation and mechanism. Deák and colleagues (Deák et al., 2017) employed a microcoding scheme to investigate how parent-initiated joint attention is supported by gaze and manual actions. Most notably, the researchers found development of joint attention in parent-child dyads is the result of a co-modulation of behaviors between members of the dyad across months' worth of interactions. From this, the researchers argued that joint attention is complex, interactive, and is supported by the maturation of the child's sensorimotor networks, which affords engagement in multimodal communication. Not surprisingly, microcoding parent-child interactions has become increasingly popular in joint attention research and is leading to new hypotheses and directions for future research.

As an extension of the coding scheme outlined above, we also provide guidelines here for identifying the sensory components of bids—including auditory, visual, and tactile cues. Multimodal cues are a powerful source of information for newborn and young infants in that auditory cues commonly result in visual attention (Kaplan & Werner, 1991; Mendelson et al., 1976). More recent studies support the more general idea that multimodal information supports vocabulary development (Trueswell et al., 2016), establishment of category labels (Clark & Estigarribia, 2011), sustained attention (Suarez-Rivera et al., 2019), and joint attention (Gabouer et al., 2018; Gabouer et al., in prep). By interrogating whether bids that consist of one sensory modality or various combinations of sensory modalities result in more or less joint attention, we can expand our understanding of infant development in general, and the influence of different interaction styles in particular.

Coding Scheme in Practice

In the research described above, our lab employed a coding template built using EUDICO Linguistic Annotator (ELAN). ELAN is a custom language annotation software program created by the Max Planck Institute for Psycholinguistics (The Language Archive, Nijmegen, The Netherlands). ELAN allows for multimodal analyses of language and other behaviors (Wittenburg et al., 2006) and is available free of charge (http://tla.mpi.nl/tools/tla-tools/elan/). The template was built to allow for transcription of any auditory information, as well as a dependent "layer" to identify the modality information. Each of these layers is called a tier. The template is built by starting with two tiers labeled "Parent Initiated Joint Attention" and "Child Initiated Joint Attention." Then a new "Controlled Vocabulary" is added. A controlled vocabulary creates a forced-choice dropdown list of all the bid outcome (e.g., successful, failed, no active verification, incidental) and modality options (e.g., auditory-object noise, visual-tactile) that can be selected to describe an interaction. The controlled vocabulary is the content of a "Linguistic Type", which specifies the parameters of the controlled vocabulary. The linguistic types, which were label as "Bid Outcome" and "Modality", can be added to a tier to provide the dropdown list when a certain tier is selected and annotated. After the creation of the controlled vocabulary and using the controlled vocabulary to specify the linguistic type, you can then apply the linguistic type to tiers. Two new dependent tiers are added to attach the instance of bid outcome to the modality used by the initiator—these tiers are labeled "Parent-Initiated Modality" and "Child-Initiated Modality". These tiers are then associated with the linguistic type "Modality", which will prompt the dropdown of the modality or combinations of modalities when this tier is selected. Additionally, these tiers are assigned a "parent tier" with creates a hierarchical structure in the template.

Conclusions

What is Joint Attention?

If our goals are to identify the mechanisms underlying the development of joint attention abilities, as well as to understand how parents can better support children's attentional development, researchers must first agree on what joint attention is, or at the very least clearly define the construct of interest. Given the developmental implications of successful engagement in joint attention, the phenomenon has become an important developmental milestone. However, it is difficult to measure such a milestone when its behavioral manifestation is characterized in so many different ways. We hope we have made it clear that what qualifies as joint attention in parent-child interactions has myriad forms (Siposova & Carpenter, 2019). The operationalization of joint attention will likely continue to be informed by mechanistic understanding of what supports development of the skill itself—a topic for future research—we commit to providing a clear definition of what we consider joint attention to be and urge other researchers to do so as well.

Clinical and Other Applications

The delay or deficiency of joint attention abilities is a key diagnostic indicator for a range of atypically developing populations. In particular, children with Autism Spectrum Disorders (ASD) commonly exhibit deficits in joint attention (Mundy, 1995). Greater understanding of joint attention in infancy promises to yield important insights into the development of language and social cognition, and directly informs developmental models of autism (Elison et al., 2013), and further, can inform interventions for children at-risk for or diagnosed with autism (Kasari et al., 2012). In addition to children at-risk for or diagnosed with ASD, deaf children who are born into hearing families can experience similarly impaired joint attention abilities (Nowakowski et al., 2009). Interestingly, impairment in this population highlights the social basis for joint attention (i.e., due to the mismatch in hearing status between the parent and the child) rather than its basis in a neurodevelopmental delay. In other words, mechanism is hard to get at, regardless of population, but information from a range of populations can help fill out the picture of the component parts underlying joint attention. For example, because joint attention can serve as an important scaffold for children to learn about communicative intent, one can imagine greater deficits in joint attention in deaf children of hearing parents who do not use sign language. This is an empirical question, the answer to which will rely on systematic implementation of an objective coding protocol. In short, a greater understanding of the construct of joint attention must include an agreed-upon definition and clear operationalization of the construct itself.

Adjusting the Protocol to Fit Different Needs

There are several ways in which the protocol outlined here can be modified to address specific questions. Here we suggest a handful of adjustments that can be made to accommodate the different perspectives researchers bring to the topic, particularly with regard to time windows for different criteria, as well as to investigation of other types of engagement.

As we have noted, there are several ways to determine the amount of time an episode of joint attention should span (Abney et al., 2017). The research used to develop the current coding protocol is commonly a parent-child free play, in which the dyad is left alone with several developmentally appropriate toy options and recorded without interference. However, these free-play tasks are not the only context in which joint attention is worthy of assessment. Additionally, the child participants in the studies that prompted our coding protocol are of varying ages but range from infant to toddler. Instances of joint attention outside of this age range are much less predictable, largely due to the lack of research in this population (see Bean & Eigsti, 2012; Nowakowski et al., 2011for exceptions). As the type of task and the participant age vary, the coding protocol can also vary either informed by prior research or based on a data-driven approach.

Recent research also varies in whether to include the intentionality component that we outline here. The current protocol uses intentionality as a requirement for bid success. However, findings from eye-tracking suggests that intentionality need not preclude language learning (Yu & Smith, 2013) or influence an infant's ability to sustain attention (Suarez-Rivera et al., 2019). The importance of intentionality in relation to joint attention remains a point of debate, particularly as it depends on the age of the child and type of task a dyad is engaging in. As such, the current protocol can be adapted to track and compare bids with simple modifications to the decision tree. To implement identification of incidental engagement, or successful engagement that does not include active verification on the part of the initiator, one can simply code for the bids labeled here as "Not Coded" (Figure 1). The label of choice can then be added to the Controlled Vocabulary in ELAN, resulting in the forced dropdown menu containing a code for bids that would traditionally fail at step 3b (Figure 1). The incorporation and assessment of these different types of engagement can help move forward our understanding of dyadic relationships. Of importance, is to successfully define and differentiate each type of attentional state for which we are interested. In the above example, adding a label for incidental engagement should not be immediately collapsed with those interactions prompted by an intentional bid.

We have developed our joint attention coding scheme based on our perception that explicit and objective guidelines were needed. We are aware that much joint attention research, including our own, is centered on white, suburban, upper-middle class families, and that joint attention may not look in the same across diverse populations. This remains an open question. A recent cross-cultural investigation found that the western model of joint attention—one that emphasizes the visual modality—does not generalize to ethnically diverse dyads (Little et al., 2016). Moreover, joint attention can be achieved through other modalities, such as via touch (Botero, 2016). Thus, we encourage application of our multimodal coding scheme on a range of populations. There is much to be learned on that front. We are also excited about new approaches to answering long-standing mechanistic questions about joint attention that are possible with neuroimaging techniques compatible for use with infants and toddlers. For now, we plan to continue pursuing systematic characterizations of that initiation and maintenance of joint attention in hearing parent-deaf child and hearing parent-hearing child dyads, with the goal of developing best-practice guidelines for parents of deaf children who are candidates for cochlear implantation.

Limitations and Future Directions

We are the first to admit that our coding scheme cannot serve as the basis for making claims about the origins of joint attention abilities. Rather, we have used our careful reading of seminal research, together with our own experience observing parent-child interactions, as a guide to developing a coding scheme that is objectively useable. We are adjusting our own approach as findings emerge from research that capitalizes on new techniques and technological advances (e.g., eye-tracking). However, we are compelled by the nuanced behavior that we are able to characterize through our own manual coding approach and urge researchers to consider the important finding behavioral coding continues to produce. Indeed, comparing these approaches will lead to fruitful research. For example, one issue we see as needing to be addressed is whether overlapping looking behavior—whether coincidental or intentional—produces the same developmental outcomes. Moreover, because overlaps and contradictions in terminology have been the source of substantial confusion (Chen et al., 2020; Racine, 2013), we encourage researchers to clarify their choice of terms. All of us should define what we mean by each term we use and provide clear operationalization of the behavior(s) we are considering in any given study. Given the current confusion, any move in this direction will increase understanding and contribute in an outsized way to research advances. Ideally, a single, coherent definition of joint attention will be agreed upon, although at present that possibility seems somewhat remote.

Chapter 3

Parent-child dyads in which the parent is hearing, and the child is deaf present a unique opportunity to examine whether and how people spontaneously adjust interactions depending on the unique needs of their communicative partners. In prior research, we examined how parents of deaf children adjusted their dyadic interactions during episodes of joint attention. Findings from that work showed that hearing parents accommodate their deaf children's hearing status by using multimodal cues throughout episodes of joint attention more often than hearing parents of hearing children (Depowski et al., 2015). In spite of this, findings from the same study showed that hearing parents of hearing children spent more time overall in joint attention with their children than hearing parents of deaf children. In other words, we found that hearing parents make communicative accommodations for their deaf children when they are engaged in joint attention with them, but that they are engaged in joint attention with their deaf children less often than hearing parents of hearing children. This raises the question: how do hearing parents of deaf children initiate joint attention in the first place? The goal of the present study is to characterize how hearing parents establish joint attention with their deaf children and to compare it to how joint attention is established by hearing parents of hearing children.

Joint Attention in Hearing-Status Matched Dyads

Joint attention refers to the shared focus of two people on object. It is achieved when one person directs the other to the object of interest. For dyads consisting of a young child and a parent, periods of joint attention have been shown to facilitate the development of a range of skills, including language. The relationship between joint attention and language development has motivated extensive research on how hearing parents support the development of joint attention skills in their hearing children (i.e., hearing parent-hearing child dyads). To the degree that researchers have examined the development of deaf children's joint attention abilities (Lieberman et al., 2014), they too have focused on parent-child dyads who are matched for hearing-status (i.e., deaf parent-deaf child dyads). Shared hearing status in parent-child dyads influences language learning, as evidenced by findings that children in deaf parent-deaf child dyads develop joint attention at rates similar to their typically-hearing peers (Spencer, 2000). In contrast, children in hearing parent-deaf child dyads do not (Nowakowski et al., 2009).

Joint Attention in Hearing-Status Mismatched Dyads

Hearing-status mismatched dyads consist of conversational partners who do not both hear equally well. In terms of prevalence of hearing-status mismatches in parent-child dyads, 4.4% of children born to deaf parents are also deaf, meaning that over 95% percent of children born to deaf parents are themselves able to hear (Mitchell & Karchmer, 2004). Likewise, well over 95% of deaf children are born to hearing parents, who themselves have little to no experience of deafness (Mehra et al., 2009). In other words, to the degree there is a deaf member of a biological parent-child dyad, that dyad is more likely to be mismatched than matched on hearing status. Here we focus on hearing parent-deaf child dyads in which parents have decided to pursue cochlear implantation for their children with the goal of raising their children using spoken language.

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Cochlear implants are an assistive technology that allows a person with sensorineural hearing loss to experience the sensation of sound via direct stimulation of the auditory nerve (Korver et al., 2017). Early implantation maximizes a deaf child's access to speech during a period of heightened neural plasticity, which in turn should lead to more age-appropriate speech-language skills given sufficient spoken language input (Fitzpatrick, 2015). Thus, the earlier the child receives an implant, the better. Although the average age of pediatric cochlear implantation is steadily declining (Colletti, 2009), with some children receiving implants as young as 6 months of age (Miyamoto et al., 2017), the average age of implantation is far older (Hoff et al., 2019).

In the sample of children included in the present study—all of whom were candidates for cochlear implantation and none of whom had yet received their implant—ages ranged from 11 to 39 months. Indeed, the average age of cochlear implantation varies substantially depending on a number of factors (see Fitzpatrick, 2015). For example, because cochlear implantation is an invasive medical procedure, parents must have a child's hearing assessed by clinicians and the child must be approved for implantation by a medical team. Only at that point can surgery be scheduled, and the child implanted. Following implantation, the child must recover, at which point the child's implant can be activated and programmed (Chen & Oghalai, 2016). Finally, it takes time post-implantation for the child to recognize structure in the auditory signal that the device provides to learn from it (Bortfeld, 2019). There are many additional sources of delay that are beyond the scope of this overview to describe in detail. Suffice it to say that such delays may put pediatric cochlear implant users at a developmental disadvantage relative to children from hearing-status matched dyads, particularly insofar as timely exposure to fluent and structured linguistic input is concerned (Hall et al., 2017, 2018b, 2018a).

Particularly in cases where there is little to no sign language being used in a hearing-status mismatched parent-child dyad, as is often the case with children who are candidates for cochlear implantation, the establishment of joint attention can serve as an important scaffold for children to learn about communicative intent, as is the case for children in hearing-status matched dyads. Thus far, researchers have focused on hearing-mismatched parent-child dyads to identify strategies used by parents to engage children's attention (Gale & Schick, 2009; Lieberman et al., 2014), characterize parents' adaptive social behaviors (Nowakowski et al., 2009), and compare overall amounts of joint attention across dyad types (i.e., hearing parent-deaf child; hearing parent-hearing child; deaf parent-deaf child) (Nowakowski et al., 2009; Spencer, 2004; Spencer et al., 1992). Although these studies generally include small sample sizes and children with highly heterogeneous hearing issues, their findings show that, while hearing parents are sensitive to deaf children's communicative efforts, the overall rate of maternally-initiated joint attention is lower in hearing status-mismatched dyads. Moreover—and critical to our purposes here—deaf children in those studies were not candidates for cochlear implantation, nor did the researchers focus specifically on the *manner* in which parents engaged the children in joint attention. Therefore, in the current study we characterize the parental behaviors that lead to joint attention in hearing parent-deaf child dyads in which the child is a candidate for cochlear implantation, comparing those to behaviors observed in hearing parent-hearing child dyads in which each child is age-matched to a deaf child. In particular, we focus on the individual sensory cues or combination of cues that parents from both dyad types use in successful and failed attempts to establish joint attention with their children.

Multimodal Cueing in Hearing Parent-Deaf Child Dyads

Multimodal cueing serves an important role in parent-child communication. For example, Bahrick and colleagues helped characterize how infants' attentional biases contribute to their language development by demonstrating that infants respond to cues across the full range of sensory modalities when those cues are synchronous with one another (Bahrick, 2006; Bahrick & Lickliter, 2014). In particular, infants experience this intersensory redundancy in multimodal cues when they visually observe and hear their parents speaking to them. Such cues have been shown to aid infants in learning abstract rules about language (Frank et al., 2009), and parental talk and touch within episodes of mutual engagement supports development of children's sustained attention (Suarez-Rivera et al., 2019). Critically, whether parents provide such combinations of cues when they initiate joint attention in the first place is largely unknown**.** In previous research, we documented hearing parents' use of converging, multimodal cues when interacting with their deaf children who were candidates for cochlear implantation (Depowski et al., 2015). Specifically, we observed that hearing parents made modifications to the input they provided to deaf children *during* episodes of joint attention, using a greater range of multimodal cues than hearing parents did with hearing children, albeit with considerable variability across different hearing parent-deaf child dyads (Depowski et al., 2015). In other words, hearing parents of deaf children accommodated their children's unique communicative needs once the dyad was engaged in joint attention towards an object. But how these parents initiated joint attention in the first place remains unclear. If hearing parents are making these important modifications within instances of joint attention with their deaf children, how does the dyad become jointly engaged?

Study 1A

The goal of the current study was to build on our team's previous findings (Bortfeld & Oghalai, 2020; Depowski et al., 2015; Gabouer et al., 2018) by examining what cues and combinations of cues hearing parents use to initiate joint attention with their deaf children and to compare that to the cues used by hearing parents of hearing children. Parental attempts to establish joint attention first were classified as either successful or failed, and then were coded for the modality or combination of modalities used. We predicted that hearing parents of deaf children would engage in fewer instances of joint attention relative to hearing parents of hearing children. We also predicted that parents would combine more cues when attempting to engage in joint attention with deaf children than with hearing children.

Materials and Methods

Participants

Participants were nine severely to profoundly deaf children (females = 3) aged 22 months (M = 22.2, SD = 9.4) and their hearing parents (females = 9) and nine typically developing children (females = 5) aged 24 months (M = 24.2, SD = 11.3) and their hearing parents (females = 5). Each hearing child was matched as closely as possible based on age to a deaf child. Each family was recruited using the National Institute of Health website or via local recruitment at the respective research sites (i.e., at Stanford University or at the

University of Connecticut). All parents had at least some college education. Race and ethnicity information is presented in Table 1. All deaf children included in this study were candidates for a cochlear implant, but none had yet been implanted. All children were receiving at least one hour and no more than 3 hours of speech therapy each week, with only a subset reporting some exposure to signed communication in these sessions and/or at home (either a natural sign language, e.g., American Sign Language (ASL), or total or simultaneous communication, in which sign is used in conjunction with speech). No deaf children in this sample were receiving consistent, fluent language input in the visual modality. We observed little to no sign use in the free-play sessions, with only two of the nine parents of deaf children producing one or two simple (i.e., single word) signs in the course of the interaction. These signs were included in our coding. The study was carried out in accordance with recommendations from the Stanford University School of Medicine Institutional Review Board and the University of Connecticut Institutional Review Board with written informed consent from all participants in accordance with the Declaration of Helsinki. For young children, parents provided written informed consent.

Materials

Each parent-child dyad was invited to participate in a free-play session during a visit with their speech language pathologist at the Stanford University Hearing Clinic or during a visit to the Husky Pub Language Lab at the University of Connecticut. Matching sets of appropriate toys for the age range included here were made available during all free-play sessions (a ball, a set of large blocks, a set of stacking cups, tableware, a tower of stacking rings, and toy cars). Parents were instructed to play with their child as they would at home and the experimenter told parents she would return to the room after five minutes had elapsed. To ensure equal play session lengths, any extra time beyond the five minutes that followed the experimenter closing the playroom door—never more than 30 seconds of additional play time— was excised from each video. Videos of the hearing parent-deaf child dyads were then transmitted by collaborators at Stanford University to researchers at University of Connecticut using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at Stanford University (Harris et al., 2009). REDCap is a secure, web-based application designed to support data capture for research studies. It provided the two labs with a vehicle for validated data entry with audit trails for tracking data entry and export, as well as procedures for importing data from external sources. For the current study, REDCap was used solely as a means of secure video transfer between collaborators and was not used for any analytical/coding purposes.

Procedure

The videos were coded for initial instances of parent-initiated joint attention using ELAN (Wittenburg et al., 2006), a custom language annotation software created by the Max Planck Institute for Psycholinguistics (The Language Archive, Nijmegen, The Netherlands). ELAN (http://tla.mpi.nl/tools/tla-tools/elan/) allows for multimodal analysis of language and other behaviors and is available free of charge. We used modified coding criteria for joint attention based on the work of Tomasello and Farrar (1986), described below. Coded variables were analyzed using ELAN, Microsoft Excel, and a statistical software package.

Video Processing

Videos were reviewed for visual clarity, and Adobe Premiere Pro (CS6) was used to edit videos for the start and end time of each play session. The start time of the play session was defined as the first frame in which the testing room door was closed, leaving the parent and child alone. The end of each play session was defined as the first frame in which the experimenter opened the door to end the play session. These two values were subtracted to give a baseline length of time for the play session, to ensure that each was 5 minutes in length.

Joint Attention Coding

In the present study, parent-initiated bids for joint attention—both successful and failed—were coded and quantified. Here, we use the term "bid" to describe a purposeful action on the part of the parent with the intent of directing his or her child's attention to an object of interest. A successful bid for joint attention consisted of three criteria: a parent's bid for the child's attention, gaze switching by the parent between the object and the child, and a response from the child that lasted for at least 3 seconds and demonstrated the child was aware of the interaction (see Figure 1). A successful bid also could occur if the parent shifted the child's attention from one object to another using one of the mentioned techniques. The child could respond to a bid by using pointing, gaze following, tapping or touching the parent, touching the object of interest, deliberate waving within the parent's visual field, changing affect, and/or producing language. The child was required to engage with the parent as indicated by one or more of these responses for three seconds or more (Bakeman & Adamson, 1984) for the bid to be considered successful. If the parent attempted to initiate interaction with the child, and the child did not respond within three seconds of the parent's bid, the instance was coded as a failed bid (Figure 1). Additionally, if the parent did not engage in gaze switching behavior (i.e., looking from the object back to the child) the instance was not considered a bid and was not coded (Figure 1).

To identify bids for joint attention in ELAN, the onset of a parent's behavior (e.g., reaching, showing) was marked as the onset of the bid. The end of this period was marked when the parent completed one gaze shift between the infant and the object. If the child made no gaze shift, the end of the period was marked at the end of the three second time-window of opportunity for the child to respond (Figure 3, Seconds 0-3), and the instance was coded as a failed bid. Our criteria for what constituted initiation of a bid for joint attention were conservative: the parent had to demonstrate a look to the toy and a look back to the child to ensure the child was engaged. Additionally, a five second rule of engagement was used: if the child disengaged and re-engaged within this five second window (Figure 3), the episode continued, and no new initiation could be coded. Similarly, there was a five second rule of disengagement (Figure 3): a joint attention episode was terminated if the child no longer engaged with the object/parent for five seconds.

Modality Coding

All parent-initiated joint attention bids were then coded separately based on parental use of the following modalities: auditory, visual, tactile, auditory-visual, auditory-tactile, visual-tactile, and auditory-visual-tactile. Only instances in which attempts were made to initiate joint attention were included in the coding presented here (Figure 3, Seconds 0-3, indicated by red circle). Actions that occurred within episodes of joint attention (Figure 3, Seconds 3-7) were not coded, as here we only were interested in the precursors to joint attention. Only those actions made by a parent within the time window between bid initiation and child response (Figure 3, circled region) were considered in our coding of bid modalities.

Auditory. The auditory modality included using sound to gain the child's attention. This include language, humming, other vocal sounds (e.g., 'psst!'), making noise with a toy, and clapping outside of the child's visual field.

Visual. The visual modality involved the parent moving a hand or an object into the child's visual field to get the child's attention. This included behaviors such as waving, gesturing, reaching, pointing, offering a toy, holding an object in the child visual field, or changing affect.

Tactile. The tactile modality involved interactions initiated via touch, direct or indirect. This included tapping or touching the child, tickling, hugging, touching with a toy, or physically moving the child to direct their attention.

Auditory-visual. The auditory-visual modality was a multimodal cue that included the parent using both an auditory and a visual behavior to gain the child's attention. This included, but was not limited to, gesturing while talking, presenting a toy while describing it, responding to a visual event, or changing affect while producing a sound.

Auditory-tactile. The auditory-tactile modality was a multimodal cue that involved the parent mixing an auditory and a tactile cue. This included touching the child with a toy while describing it or making the accompanying noise (e.g., touching the child with a toy and describing the feature).

Visual-tactile. The visual-tactile modality was a multimodal cue that involved the parent using both a visual and tactile cue. This included directing the child's attention to a toy not currently within the visual field by physically moving the child (e.g., while the child was sitting in the parent's lap, the parent turns the child to guide him or her to look at new toys).

Auditory-visual-tactile. The auditory-visual-tactile modality was a multimodal cue that included the use of sounds, visual information, and touch in an effort to gain the child's attention (e.g., the parent showed the child the toy, while labeling the toy, and tickling the child).

Data Analysis

Inter-rater Reliability

Approximately 25% of the sample was dual coded for reliability. Reliability was calculated by examining the percent overlap in the quantity of successful and failed bids, as well as by comparing the modality code attributed to each instance of joint attention. Cohen's κ (McHugh, 2012) was calculated to determine the extent of agreement between the annotations of the first and second coder regarding the identification of successful and failed bids. Results showed there was substantial agreement between coders in judging which were successful bids, $\kappa = .63$, 95% CI [0.557, 0.703], and near perfect agreement between the coders in identifying failed bids, $\kappa = .85$, 95% CI [0.777, 0.923]. The average overlap/extent ratio between coders' modality identification was 76% for the successful bids and 80% for the failed bids. All disagreements between the two coders were resolved through discussion between the coders and the first author.

Joint Attention Modalities

Seven modality metrics were computed for both successful and failed bids to initiate joint attention. This was done by extracting the total number of occurrences of each modality cue used during an attempt to gain a child's attention, whether it was a successful or a failed bid. Proportional data were then calculated by comparing the raw number of modality-specific bid types to the overall number of bids throughout the interaction (e.g., number of auditory-visual bids relative to the total number of parental bids). These data were compared as a function of child hearing status. Mann-Whitney *U* analyses were used to compare the proportion and raw totals of modality use across hearing parent-hearing child and hearing parent-deaf child dyads. In contrast to a t-test, this non-parametric test is used when the sample is small, and the distribution of the data is unknown or not normally distributed. Thus, it is more robust against outliers and heavy tail distributions (i.e., non-normal distributions) as in these data.

Results

There were no instances of tactile-only modality use in either the successful or failed bids for joint attention, and there were no instances of auditory-tactile or visual-tactile combinations in failed bids. Therefore, these modalities were excluded from further analysis. Table 2 shows the overall number of occurrences of each modality by bid type and dyad hearing status.

Proportion of Bids

Proportions were calculated by comparing the raw number of successful and failed bids to the overall number of bids throughout the interaction. We first used a proportion analysis to determine whether there were differences in overall proportions of bids by dyad type (i.e., hearing parents of hearing children may just bid for attention more than hearing parents of deaf children, and therefore would have more chances for success). For the initial analysis, we compared the proportion of success and failure rates of hearing parents of hearing children and hearing parents of deaf children at engaging their children in joint attention. There were no significant differences by dyad type (hearing parent-hearing child vs. hearing parent-deaf child) in proportion of successful bids for joint attention ($U = 51.5$, $p = 0.35$), nor of failed bids ($U = 29.5$, $p = 0.35$). Contrary to our predictions, neither group of parents was better nor worse at initiating joint attention overall. Because there were similar raw numbers of bids across both dyad types that were classified as successful and failed, for the remaining analyses we use frequency of occurrence as the basis for our comparisons.

Successful Parent-Initiated Joint Attention

A Mann-Whitney test was used to compare the total number of successful engagements in joint attention across hearing parent-hearing child dyads and hearing parent deaf child dyads. Results indicated that there was no significant difference in the number of successful parental bids for joint attention using the unimodal auditory ($U = 49.5$, $p = 0.45$) or the unimodal visual ($U = 39$, $p = 0.93$) cues by dyad type. Additionally, there were no significant differences by dyad type in the number of successful bids for joint attention initiated via multimodal cues: auditory-visual ($U = 48.5$, $p = 0.51$), auditory-tactile ($U = 45$, $p = 0.73$), visual-tactile ($U = 45$, $p = 0.73$), or auditory-visual-tactile ($U = 35$, $p = 0.66$).

Failed Parent-Initiated Joint Attention

Again, we used Mann-Whitney tests to compare the total number of time parents failed to engage in joint attention with their child across dyads based on the child's hearing status. We found no significant difference in the number of failed attempts to initiate joint attention using unimodal auditory ($U = 31.5$, $p = 0.45$) or visual ($U = 41.5$, $p = 0.97$) cues by dyad type. Additionally, there was no significant difference in number of failed bids for joint attention using either auditory-visual cues ($U = 37.5$, $p = 0.83$) or auditory-visual-tactile cues ($U = 27$, $p = 0.25$).

Discussion

The purpose of the present study was to build on our previous research (Depowski et al., 2015) and characterize patterns of modality use in parent-initiated bids for joint attention in hearing parent-deaf child dyads and compare them to patterns in hearing parent-hearing child dyads. Our goal was to detail whether and how hearing parents of both deaf and hearing children use unimodal and multimodal cues in their attempts to direct their children's attention. To that end, we developed a microcoding technique that focused on three critical features of joint attention, while also characterizing the patterns of multimodal cues that parents used to direct their children's attention to an object of mutual interest. We predicted that hearing parent-deaf child dyads would engage in fewer instances of joint attention relative to those in hearing parent-hearing child dyads. Moreover, we expected to observe hearing parents using a range of modalities when attempting to engage in joint attention with their deaf children, and to do so more than hearing parents of hearing children. Neither of these predictions was supported by our findings. We next address the basis for these predictions and potential sources of variability in the data relative to previous work.

Joint Attention Coding

Joint attention is often quantified using structured assessment procedures that incorporate specific activities to elicit targeted behavior. For example, two structured measures frequently used in clinical domains are the Early Social Communication Scales (ESCS; Seibert et al., 1982) and the Communication and Symbolic Behavior Scales (CSBS–DP; Wetherby & Prizant, 2002). The ESCS was designed to measure joint attention and related behaviors in typically developing toddlers (Morales et al., 2000; Mundy & Gomes, 1998), while the CSBS was developed to evaluate verbal and non-verbal communication in children at risk for communication and language impairments. These standardized measures emphasize gaze, point following, and point production. However, as should be apparent from the data reported here, a variety of other manners of communication can be documented during interactions with children from both typical and atypical populations. This is particularly relevant to deaf children of hearing parents who are candidates for cochlear implantation who do not know sign language. Detailed examination of the communicative attempts that take place in more naturalistic interactions, as reported here, should reveal more nuanced information about what works to support communication—and what does not—than the more structured scenarios used in clinical research (see Roos et al., 2008 for such an approach in children with Autism Spectrum Disorder).

While prior research is consistent in showing that hearing parents of deaf children accommodate their deaf children during interactions (Depowski et al., 2015; Lieberman et al., 2014), findings from the present study indicate that hearing parents appear to use the same strategies to initiate joint attention with their hearing children. In the present study, we focused on the moments that led up to successful joint attention during free play, as well as on what happened prior to failed attempts by parents to establish joint attention with their children. Surprisingly, we observed no difference in outcome (successful or failed) of bids for attention by dyad type. This is in contrast to research focusing on parent and child behaviors *within* episodes of joint attention. Why is this? The coding scheme employed in the present study is one that we have carefully constructed based on extensive prior research by others (Tomasello & Farrar, 1986; Nowakowski et al., 2009), and arguably captures what researchers intended when joint attention was initially documented and classified (e.g., Bakeman & Adamson, 1984). An issue for consideration in future research is whether episodes of joint attention are being coded consistently across different labs. Given other notable differences between the present study and earlier studies that included deaf children, in particular that the deaf children included here were all candidates for cochlear implantation while the previous studies included parent-child dyads who used a range of communication techniques (i.e., formal sign language; auditory-verbal; oral only; auditory-verbal plus oral; total communication), it is clear that more research is needed to answer this and other questions. For now, we further interrogate the nature of the interactions we observed in the present study.

Study 1B

Our failure to find a difference in parental multimodal cue use during instigation of joint attention in Study 1A could be due to a number of factors, including our small sample size, the small sample size of the previous studies serving as our basis for comparison, the strict coding criteria we employed to identify episodes of joint attention, and the unique aspects of our particular sample of deaf children (i.e., deaf children who were candidates for cochlear implantation and who were not regularly exposed to sign language). To better characterize the interactions we observed in the present study across hearing parent-deaf child and hearing parent-hearing child dyads, we next conducted analyses with a focus on two additional aspects of parental input: 1) parental speech production during initiation of joint attention, and 2) parental use of touch more generally (i.e., throughout the free-play session). We next detail our rationale for examining these aspects of parental input.

Hearing parents typically rely on spoken language (produced in the auditory modality) to communicate with their hearing children. Recent research has shown that the hearing parents of deaf children who have received cochlear implants provide comparable amounts of spoken language input to their child as do hearing parents of hearing children (Vanormelingen et al., 2016). Of course, the point of an implant is to help deaf children hear and thus learn spoken language, so this is not entirely surprising. However, it does suggest that parents who already communicate primarily in the auditory modality prior to having a deaf child may not change the nature of their input to their children if they decide to pursue cochlear implantation once they do have a deaf child. Remarkably, there are no evidence-based guidelines available to inform hearing parents how to interact with their deaf children. We will address this further in the general discussion.

Another way that hearing parents can engage their profoundly deaf children is through touch. Whether hearing parents use spoken language with their children or not, hearing parents of profoundly deaf children must rely on some non-auditory sensory cue or cues to capture their children's attention and engage them socially, and touch is one cue that parents of deaf children can rely on. Indeed, it is a sensory modality available to children even prenatally (Marx & Nagy, 2017). Tactile cues are an effective means of establishing social contact when audition is not available. Previous research has found that in hearing-status mismatched parent-child dyads, hearing mothers of deaf children have been found to use both tactile and visual information to communicate with their deaf children, and they do so more than mothers in hearing parent-hearing child dyads (Waxman & Spencer, 1997). Thus, touch is a way for parents to engage with their children when spoken language is not an option. Whether or not touch is a factor that helps distinguish interactions of the two dyad types included here likewise merits investigation.

Materials and Methods

The 18 participants and the accompanying videos used to complete to joint attention coding and analysis in Study 1a were re-coded for our secondary analyses. Again, we used ELAN to annotate 1) the parental utterances during the bids for joint attention and 2) the overall instances of touch by parents. The coding criteria and inter-rater reliability for each of the newly coded variables of interest are presented below.

Mean Length of Utterances in Bids for Joint Attention

We examined the use of auditory language cues in parents' bids to initiate joint attention by calculating the mean length of utterance (MLU) based on Brown's (1973) protocol for determining the number of morphemes in an utterance. Utterances were identified in ELAN by transcribing any spoken language from the parent during an attempt to initiate joint attention. Then, utterances were quantified and coded for the number of morphemes contained in each. Here, an utterance is defined as the natural way in which speech is broken up by phrases. Commonly, an utterance is speech that is bounded by silence. Each coded utterance could be a word (e.g., "Look!"), a group of words, or a complete sentence. In our sample, each bid containing parent language was counted as one utterance, based on the coding criteria and the definition of an utterance.

The overall parental MLU was calculated across all parental bids for joint attention, including both successful and failed bids, and then separately coded for whether the utterance was part of a successful or failed bid. Instances in which a parent used an auditory cue that resulted from an object noise (e.g., shaking a toy, tapping the floor) were excluded from these analyses. We hypothesized that parental MLU during bids to initiate joint attention would be significantly lower in hearing parents of deaf children.

Parental Use of Touch

In our secondary analysis comparing parents' use of touch overall across dyad types, we coded episodes of parental touch across the entirety of each play session (e.g., not immediately prior to or within episodes of joint attention). This included identifying instances in which any type of touch was used by the parent, either touch of the child directly (e.g., with a hand) or indirectly (e.g., with a toy), and regardless of the attentional states of either the parent or child.

In ELAN, touch was coded for duration, as well as raw number of instances. Coders identified any and all instances of intentional touch throughout the play session – from adjusting the child position or location in the room to tapping them atop their head with a soft toy. Instances of incidental contact, such as grazing, were not coded. Rather, we were interested in how parents used purposeful touch to interact with their child. The annotation started at the initial point of contact and persisted as long as the parent maintained contact. In the instance parents removed their hand or toy from the child for less than 1 second (e.g., tapping on the child), this was coded as one continuous touch. This code ended when the parent was no longer in contact with the child for longer than 1 second. Here, we hypothesized that hearing parents of deaf children would use touch more often in their interactions.

Inter-Rater Reliability**.** Again, about 25% of the MLU and touch codes were randomly selected for reliability coding. Reliability for the count data was calculated using Krippendorff's Alpha-Reliability (Krippendorff, 2011). Krippendorf's alpha (α) is a reliability coefficient developed to measure the agreement between observers drawing distinctions among typically unstructured phenomena in the form of nominal data and is suited for small samples sizes. The reliability ratings for the MLU analysis were done for the number of total utterances, as well as the length of each utterance. In terms of total number of utterances by a parent across all bid types, the agreement between coders across 22 decisions was $\alpha = 0.788$. The agreements between the 2 coders regarding the MLU per utterance was $\alpha = 0.763$, across 56 decisions. We also calculated a reliability score for the touch data using Krippendorff's alpha. The agreement between the 2 coders across 12 decisions was $\alpha = 0.766$, where 1.0 is perfect agreement.

Results

Parental MLU

We examined whether the MLU used by parents in either dyad type was related to a successful or failed bid for joint attention. When comparing the MLU for successful parental bids for joint attention across dyad types, we found a significant difference in the length of utterances that hearing parents of hearing children used relative to the length of the utterances that hearing parents of deaf children used ($M_{HH} = 5.53$ vs. $M_{HD} = 3.21$; $U = 10$, $p = 0.036$). Interestingly, the MLU of utterances produced in failed bids for joint attention did not differ across dyad types. There was no difference ($U = 46.5$, $p = 0.31$) in the MLU of utterances produced by hearing parents of hearing children ($M_{HH} = 3.44$) and hearing parents of deaf children ($M_{HD} = 2.53$).

Parental Touch

We also compared to the amount of tactile contact exhibited by parents throughout the entirety of the play session. Although across dyad types, parents did not appear to use touch differentially to initiate joint attention with their children, a Mann-Whitney test showed that *overall* use of touch was greater for hearing parent-deaf child dyads ($M_{HD} = 4.2$) than for hearing parent-hearing child dyads ($M_{HH} = 1.56$; $U = 17.5$, $p = 0.0466$).

Discussion

In an effort to further characterize the nature of the interactions between the two dyad types included in this study, we ran two additional sets of analyses. The first focused on parental MLUs during bids for children's attention, including any bids in which the auditory modality was used, either alone or in combination with other cues. In this case, we found a significant difference between dyad types, with hearing parents of hearing children producing more complex utterances—as indicated by MLU—than hearing parents of deaf children. Notably, this effect was carried by the successful bids for attention, with no such difference across dyad types emerging for failed bids. The lack of a significant difference in parental MLU during failed bids is intriguing. Perhaps overall, parents of deaf children produce shorter, less complex utterances overall in bids for joint attention, with some proving successful and others not. In contrast, when hearing-parents of hearing children produce such utterances, their children are less responsive and thus such bids are less likely to be successful.

Whether the adjustment is deliberate is unclear, although it is worth keeping in mind that these parents decided to pursue cochlear implantation for their deaf children and, for the most part, used spoken language (rather than sign) with them throughout the free-play session. The decision to pursue an implant may provide more motivation for these parents to speak as usual, in which case the difference we have observed here would be surprising, because they are not speaking comparably to the other parents in their successful bids. On the other hand, the parents of deaf children may speak as normally as they think is realistic for their deaf child to understand, and thus different relative to how they would speak to a hearing child. There is a lack of evidence-based information available to guide hearing parents on how to interact with their deaf children prior to implantation; thus, it is difficult to draw conclusions about whether the reduction in parental MLU we have observed was intentional or not.

Another notable observation from this analysis of parents' MLUs was how two of the deaf children managed to respond to every spoken bid produced by their parents. To be clear, all of the children in this study failed newborn hearing screening and were characterized in their audiological profiles as severely to profoundly deaf. How then were these two children able to respond to their parents' spoken bids for attention? Upon further investigation—and in support of the utility of multimodal communication—our analyses revealed that the speech to which these two children responded was consistently paired with a cue from another modality (most commonly a visual cue). In other words, the multimodal nature of parental interactions supported the deaf children's ability to respond to their parents' spoken bids for their attention, highlighting the importance of multimodal cue use to children's understanding of communicative intent.

In addition to examining MLU in bids for joint attention, we quantified any tactile events that took place between parents and children through the play session (i.e., parental touching of children either directly or indirectly both in and outside of bids for joint attention). This additional analysis revealed a significant difference across the two dyad types in the amount of touch used by parents, with parents of deaf children touching their children significantly more often than those of hearing children. Differences in the use of tactile engagement has been observed in previous research (e.g., Spencer, 2004), although those findings were based on a very small sample and the children were not candidates for cochlear implantation. Thus, touch as a communicative device for use with this population of children merits further investigation.

General Discussion

The goal of the current study was to establish whether and how hearing parents of deaf children depart from patterns of behavior typically observed in hearing parents of hearing children to direct children's attention. Rather than observing differences, we found that parents in both dyad types produced similar behaviors when establishing joint attention with their children. For example, we predicted that hearing parents of hearing children would most often rely on a unimodal modality to initiate joint attention. However, we found no difference in the average number of unimodal and multimodal bids used by parents across the two dyad types. Moreover, the vast majority of bids produced by both dyad types combined auditory with visual information.

Although there is limited research on the role of the parent in hearing parent-deaf child dyads in establishing joint attention, the research that has been conducted thus far has demonstrated that hearing parents behaviorally accommodate their children's hearing status (Lieberman et al., 2014). However, this work did not compare successful and failed instances of joint attention, nor did it quantify the specific cues parents used to establish joint attention. The lack of clear differences in parental behavior across dyad types in the present study indicates that more work is needed to assess the role that hearing parents play in initiating joint attention with their deaf children, particularly when the deaf children are candidates for cochlear implantation. While not significant, hearing parents had more total successes when using the auditory modality alone with hearing children; though hearing parents of deaf children likewise incorporated the auditory modality into their bids for children's attention. Although the deaf children in these dyads did not have access to the auditory modality, their parents used that modality as often as parents of hearing children. On the other hand, our secondary analyses revealed that the nature of the spoken language produced during bids for joint attention did differ between dyad types. Hearing parents of hearing children produced more complex utterances—specifically during bids for attention that proved successful—relative to hearing parents of deaf children. If, indeed, the directive for parents who plan to have their children implanted is to speak to their children as they normally would, our data reveal that this was not happening in these free-play sessions.

Aside from producing more complex speech to hearing than to deaf children, our results suggest that parents from both dyad types used the auditory modality in conjunction with other modalities, supporting arguments that communication that takes place across multiple modalities more effectively elicits children's attention. Indeed, both hearing and deaf parents have been shown to engage their children during play interactions in ways that guide children's attention to objects as well as to the social world (Koester & Lahti-Harper, 2010), so called "intuitive parenting." Given the present study's findings that hearing parents often use the auditory modality with their deaf children despite the children having limited-to-no access to the auditory modality, this may be characterized as intuitive parenting as well (parent-interaction guidelines notwithstanding). Clearly, more research is needed on the role that the auditory modality plays in the establishment of joint attention between hearing parents and their deaf children, whether or not the children are candidates for cochlear implantation.

Applications for Intervention

Our findings point to the potential for therapeutic approaches that emphasize parental use of multimodal cues to establish and maintain joint attention with children, regardless of a particular child's hearing status. Such an approach may facilitate language development in children more generally. For deaf or hard-of-hearing children who are candidates for cochlear implantation—particularly if the parent is opting to use spoken language without any accompanying sign language—such multimodal communication may be critical in providing a foundation for the child's understanding of communicative intent. Likewise, greater focus on how parents use touch when establishing joint attention with their children may inform the structure of future therapeutic approaches. Given the evidence observed here and elsewhere (Akhtar & Gernsbacher, 2007) that joint attention can be established via non-auditory (e.g., tactile) means, it is not surprising that parents and their children—regardless of hearing status—use such means to communicate. Finally, although this is an exploratory study, the findings reported here highlight the utility of moving beyond standardized measures of joint attention to obtain rich, ecologically valid data on parent-child interactions for the assessment of development in both typically and atypically developing children.

Limitations and Future Directions

The findings from the present study are limited in a number of ways, not least by our small sample size. Previous studies (e.g., Lund & Schuele, 2015) have found no differences in audio-visual input from hearing parents to children with cochlear implants and to age-matched children with normal hearing, only to have those differences emerge when the comparison group was matched for vocabulary size. Such a manipulation is one possibility for extending the research presented here. Other approaches are needed to fill the critical gaps that exist in information about the effectiveness of different manners of communicating with a deaf child who is a candidate for cochlear implantation. For example, assuming spoken language is the intended outcome, there is currently little evidence supporting the use of both sign and oral language in combination relative to oral language only for deaf children who are candidates for cochlear implantation. To be clear, while there is no evidence that adding sign language facilitates spoken language acquisition (*cf*. Hall et al., 2017, 2018a, 2018b), there is also no conclusive evidence that adding sign language interferes with spoken language development (Fitzpatrick, 2015). Needless to say, cohort studies of communication methods for the current generation of pediatric cochlear implant users—both pre- and post-implantation—are sorely needed.

Our approach establishes a means by which specific behaviors produced by participants in a dyad can be tracked over time. In particular, given substantial evidence of the association between joint attention and successful language development (see Morales et al., 1998), understanding how parents accommodate children's unique communicative needs is an important exercise. If deaf children cannot access the auditory modality being used in their environment (i.e., spoken language), how can that child respond to bids for attention presented in that modality? In the current study, we did not differentiate among the effectiveness of different auditory cues used by parents (i.e., spoken language, noise made by a toy) in their bids for children's attention. However, hearing parents of both hearing and deaf children used auditory information as a means of engaging in their children in joint attention, and thus it is an open question how deaf children experience this information. Perhaps, because the parent is frequently speaking to the child, the child uses the visual cues of a moving mouth to infer that there is something worth attending to in the environment. If so, parent vocalizations may indeed be a better cue for deaf children than an auditory cue provided by shaking a toy, for example. And how will such experiences pre-implantation will influence the child's sensitivity to these attempts post-implantation? These are important issues that to address in future research.

Overall, the present study demonstrates the utility of detailed tracking of parents' multimodal sensory input during interactions with their children as a factor in parent-child communicative success. Here we observed that parents of both deaf and hearing children converged in their use of multimodal cues in support of successful interactions with their children. However, we also observed important differences in the complexity of the speech that parents from the two dyad types used and the amount they touched their children throughout the interaction. While the current study did not provide evidence for the effectiveness of multimodal relative to unimodal cues for establishing joint attention in hearing-status mismatched dyads, it did highlight the degree to which parents—all parents—use combination of modalities in interactions with their children. Additional research that includes many more parent-child dyads will be needed to determine whether the various cues are more or less effective when used in isolation rather than in combination, regardless of child hearing status. Such findings will have implications for specific interventions for deaf and hard-of-hearing children who are candidates for cochlear implantation, as well as for language development and support of attentional allocation in all children.

Chapter 4

The ability to engage in interactions involving one person and one object is a critical skill for social engagement, and as such is a developmental milestone for young children. This skill, termed joint attention, emerges around 9 months and is typically well-established by 18 months (Mundy & Gomes, 1998). Consequently, researchers have focused on this narrow age range, with disregard to any potential changes to the interaction style as children become more sophisticated social partners. In particular, initial and recent investigations of joint attention rely on the assessment and description of children who have yet to enter formal schooling. This has resulted in a limited picture of how joint attention unfolds once children have readily acquired the skill.

The current study aimed to address this issue through a semi-structured observation to better understand how older, preschool-aged children and their parent respond to and initiate bids for joint attention. We employ a novel coding protocol to code and track parent and child bids for joint attention, in addition to the outcome of the bid (Gabouer & Bortfeld, 2021). Specifically, the coding protocol allows for the moment-to-moment coding of parent- and child-initiated bids for joint attention, as well as the crucial moments that follow which indicate how the target of these bids reacted and whether successful engagement resulted from the bid or not. This is the first study to use the protocol to code children as the initiator of the bids, and the engagement in joint attention of children this age more generally. The parents are asked to engage with their child and a wordless picture book as they would at home. This prompt, as well as the likely familiarity with books, creates an ideal environment to observe these bouts of joint attention.

We are also interested in what types of sensory cues parents and children use to initiate joint attention with the other. Not surprisingly, multimodal cues have been shown to aid infants in learning abstract rules about language (Frank et al., 2009) and support children's sustained attention (Depowski et al., 2015; Suarez-Rivera et al., 2019). Moreover, tactile contact by a caregiver has been shown to be an important guide in directing infant attention (Botero, 2016). Finally, converging multisensory cues have been found to contribute to neural tuning in early infancy (Werchan et al., 2018), further indicating that infants' perceptual attention is shaped by multimodal sensory cues. In other words, engaging infants with multiple sensory modalities is critical to their early perceptual learning and subsequent development. The documented importance of multimodal and redundant cueing in early development warrants the investigation of the use and implications of such cues in dyads of parents and preschool-aged children. Our understanding of joint attention is better served through the use of coding protocols that incorporate the multiple modalities parents and children actually use in their interactions.

Initiation of Joint Attention

Developmentally, we note that infants are first able to respond to joint attention, and that a successful response is built on visual skills such as gaze and point following. As infants grasp the ability to respond to joint attention, they progress to directing others' attention and behavior (Carpenter et al., 1998; Mundy et al., 2007). Until they begin walking, infants are not initiating joint attention by bringing or showing distant objects (Brandone et al., 2020; Walle, 2016) as crawling limits their access to manipulate items with their hands. Instead, infants begin to point to or reach for things in an effort to direct

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another's attention beginning around 10 to 12 months of age (Tomasello et al., 2007). Similarly, Bretherton and Bates (1979) found that initiating requests for items increased consistently in terms of frequency between 9 and 13 months. While infants appear to rely on an adult's visual gaze for social information relatively early, there is little information on when infants begin to use strictly gaze as a means of initiating joint attention themselves. To this effect, we see infants' preference for gesture, as opposed to gaze, to initiate joint attention (Salo et al., 2018), and infant's inclination to initiate these interactions is a significant predictor of expressive language (Mundy & Gomes, 1998).

While much of joint attention research focuses on parent-initiated instances of joint attention, there are a handful of studies that report on the reciprocal, infant-initiated piece. Much of infant-initiated joint attention is initially limited by unrefined gross and fine motor skills. Once infants understand when and how to effectively follow into an instance of shared attention, they can then begin to express and direct attention to objects of their own desire (Salo et al., 2019). Overall, the engagement in joint attention between a child and an adult relies on a very sensitive, well-timed dance of auditory, visual, and tactile information. For example, children who are better able to predict the goal of their parents' reaches also had more bids for their parents' attention (Monroy et al., 2021). This carefully constructed back-and-forth is unique to the individual dyads. The lack of data regarding how children initiate joint attention coincides with the dearth of research in this area after 24 months. With age and practice, infants become increasingly active initiators of joint attention around 15 months (Heller & Rohlfing, 2017). Yet, the present state of joint attention research has been confined to a developmental period in which infants and children are poor or unlikely initiators of joint attention. The children who participated in the current study are 3.5-5.5 years old, and therefore should be well-versed in initiating joint attention.

Joint Attention in Preschoolers

Joint attention literature is relatively limited outside the ages of 7-24 months. This is likely due to the lack of tools available to measure the sharing of attention in this older population. Most commonly, the child is seated across from a caregiver or experimenter, who then gazes or points to a location outside of the infant's immediate frame of view (Butterworth & Jarrett, 1991; Moore & Corkum, 1994). This experimental assessment of joint attention largely relies on the child's ability to follow visual cues, like pointing or eye gaze, which mature around 15 months (Morissette et al., 1995). As such, this assessment is not a useful or valid measure for children much older than this.

Around age 4, children begin exposure to formal schooling, where the attention is being directed for learning purposes (Csibra & Gergely, 2009). In order for children to master the classroom and other social contexts, they must be willing and able to initiate and respond to joint attention. Continuing with the coding protocol outlined in Chapter 2, we focus on documenting and describing the multiple sensory modalities parents and preschool children use to elicit and direct the attention of the other. Multisensory methods of teaching have recently gained traction in the pedagogical community. For example, 5-year-olds performed better in a categorical learning paradigm when presented with multisensory cues (audiovisual), compared to unisensory cues (Kirkham et al., 2019). However, older children (10 years) had better learning outcomes when presented with unimodal auditory cues as opposed to unimodal visual cues and multimodal audiovisual cues. While the outcome of the study focused on categorical learning, it provides support for the worthiness of tracking and understanding what type(s) of sensory cues best scaffold the engagement in joint attention at this age. However, there are very few studies documenting the joint attention style of older children and their parents. Until recently, it seems to have been assumed that once children are able to engage in joint attention, there is little to no change in their joint attention behaviors.

Newer work suggests that perhaps it was incorrect to assume such an adult-like state of joint attention simply because children had demonstrated proficiency. Indeed, Bean and Eigsti (2012) observed individual differences in joint attention engagement well into adolescence. Authors used a novel, developmentally-appropriate paradigm in which older children (ages 7-17 years) are prompted to engage in joint attention with an experimenter. While a large part of the results focused on the assessment's ability to differentiate between typically-developing children and those with ASD, the authors also point out that there was variability even within the group of typically-developing children (Bean & Eigsti, 2012). We follow up on these findings by using an observational, rather than a prompted or experimental, method to document and describe the engagement in joint attention in an understudied age group – preschoolers – in the hopes of uncovering a new method to assess joint attention in this group.

Joint Book Reading as an Opportunity to Assess Joint Attention

There are very few, if any, options for the assessment of joint attention in children beyond the age of 3. Yet, we know that engagement in joint attention is helpful in a variety of social interactions that children are exposed to beyond the age of 36 months, specifically within pedagogical contexts where children are engaging to learn (Csibra & Gergely, 2009; Watanabe, 2013). The current study is observational in nature, and while it was originally designed to understand how parent speech is related to socio-cognitive reasoning abilities, the novelty and composition of the book presented plenty of opportunity for children to engage and learn about each of the photos. Not surprisingly, joint book reading presents myriad opportunities for parents and children to engage in joint attention (Durkin, 1995), and is often proposed as a mechanism for vocabulary development (Bus et al., 1995). More recent research has identified implications of joint book reading, especially in younger children. For instance, reading aloud promotes linguistic diversity (Montag et al., 2015) and, when coupled with appropriate word to object mappings (i.e., joint attention; Baldwin, 1995), supports language acquisition and vocabulary development (see Farrant, 2013 for review). As such, book reading seems to be an appropriate next step in the application of our coding protocol.

Ninio and Bruner (1978), who tracked one mother-son dyad's engagement in book reading (including joint attention) from 8 to 18 months of age, found that picture book reading relies on an orderly, interactive routine. They uncovered a clear turn-taking pattern from the earliest months, and the pattern progressed as the child became able to switch roles with the mother. Anecdotally, researchers noticed that as these interactions progressed, the child began to implement what he had learned from his mother in previous interactions, such as combining vocabulary and gesture to better direct her attention (Ninio & Bruner, 1978). This pattern has been documented in other research (Heller & Rohlfing, 2017), focusing on the engagement in joint attention specifically, in which results suggest that at around fifteen months, the child begins to initiate joint attention more frequently and systematically. Researchers also found that by 23 months of age, children frequently produce questions or prompts the parents had used in previous interactions (Heller & Rohlfing, 2017). Together, these results support the idea that book reading can provide an insight into the current and future communicative patterns of the dyad and other social partners. Here, we are interested in how parents and children attempt to successfully engage in joint attention in a book-reading context. Importantly, we track how each partner uses sensory cues, such as visual gaze, to direct and follow the attention of the other.

The Current Study

We have previously found that parents frequently attempt to engage their child using multimodal cues, despite the dyad's ability to communicate proficiently in the auditory modality alone. How, if at all, does the engagement of joint attention in dyads with preschool children and their parents vary? In the current study, we aim to explore how children and parents attempt to direct the attention of the other and what factors contribute to whether the attempts were successful, or not, in engaging in joint attention. Children participating in the current study are between 3.5 and 5.5 years of age – an age at which their joint attention skills should be firmly established. Here, we investigate how the dyad uses cues consisting of one or more sensory modalities to direct the other's attention during a storybook task.

To this effect, we employ a precise coding scheme (Figure 4) to systematically identify the success or failure of each bid either member of the dyad makes, while also making note of the particular cues (auditory, visual, tactile), or combination of cues, the initiating members use in attempting to initiate joint attention with the other. While the current study lacks a precise measure of eye-gaze, we do rely on a coding protocol that tracks the initiators effectiveness and active acknowledgement of their effectiveness (Gabouer & Bortfeld, 2021). Specifically, the requirement that the initiating member must provide an active verification of the target's engagement may yield similar results to an intervention technique put forth by Guo & Feng (2013), in which parents rely on the child's visual orientation to regulate engagement in joint attention. This active acknowledgement and registration of the target's engagement also may produce differences in how the dyads share attention. Relatedly, we predict that dyads will persist in eliciting joint attention through multiple sensory modality cues. However, given the exploratory nature of the study, this is an open question. It is also possible that after children have a well-developed vocabulary and prepare to enter school, their joint attention style changes, shifting to rely more so on the auditory modality.

Methods

Participants

Parents and children included in this study were selected from a larger sample of dyads originally recruited to participate in a two-part study (taking place across two days no more than one week apart) regarding the effects of socio-economic status on social cognition. In total, 42 parent-child dyads participated in the larger study. However, the original intent of this interaction was to capture what parents were saying, rather than their actions, so often times the recording did not capture the participants' faces or the entirety of the lab space. Thus, 23 dyads were excluded due to camera placement and 6 were excluded due to moving out of view. In total, 19 dyads were included (13 female children, ages 43.7 – 66.04, M_{age}= 54.18).

Parent-child dyads were selected through a university database comprised of parents interested in participating in research related to child development. Families in the database were recruited from family events surrounding the university area. Participants were reimbursed ten dollars for each visit (up to twenty dollars total) and were given a book at the end of their second visit as a thank you. The protocol was approved by the Institutional Review Board at the University of California, Merced and each child's parent provided informed consent before participating.

The picture book task is just one activity from a battery of social cognition tasks children complete across two separate visits to the lab. Other tasks include a vocabulary assessment (TELD), an anticipatory-looking task assessing false-belief understanding, and an elicited-response measure of false-belief understanding. Parent's also completed several surveys regarding background and demographics, their beliefs about child development, and a consent form.

Materials

This study examines one task completed by the parent and child – a wordless picture book (Taumoepau & Ruffman, 2006). Dyads completed the picture book task as the last task on either the first or second day of assessment. For this specific task, the parent and child were given a bound picture book containing 26 photos of content that aims to elicit mental state talk. Of note, the photos included in the picture book were not sequential; each photo was unrelated to photo presented before or after it. Specifically, the photos in the book do not present the opportunity for the dyad to tell one cohesive story throughout the session. Rather, each page presents novel characters, emotions, referents, etc. that are mutually exclusive and cannot be predicted based on the previous pages.

Procedure

The picture book task took place in a separate room to ensure the dyad was not distracted by others in the laboratory space (siblings, research assistants, etc). Upon entry, the parent and child were presented 2 chairs, positioned side-by-side, and were offered a binder containing the picture book (see Figure 5). The parents were instructed to interact with the picture book the same way they would read through any book at home and were told they could return to the lobby when they were finished, or an experimenter would return after 10 minutes to end the task. The experimenter then left the room and the dyad proceeded to engage with the book as instructed.

Joint Attention Coding

Videos recorded during the picture book task were transcribed for parent and child vocalizations and coded for attempts to initiate joint attention from both members of the dyad using ELAN. ELAN is a custom language annotation software program created by the Max Planck Institute for Psycholinguistics (The Language Archive, Nijmegen, The Netherlands). ELAN allows for multimodal analyses of language and other behaviors (Wittenburg et al., 2006) and is available free of charge (http://tla.mpi.nl/tools/tla-tools/elan/). Overall, we were interested in any time the parent or child performed an initiation act, tracking who performed the act and what modality they used to initiate joint attention. We were also interested in whether the initiation act successfully established joint attention.

Initiation Act

Initiation acts are spontaneous but purposeful verbal or non-verbal communicative behaviors performed with the intent to direct the other person's attention. These behaviors are only coded as an initiation act if they are *not* part of ongoing interactive episode. This means if the parent-child dyad is already focusing on the same object (the book itself, or specific photos, or some aspect of a photo), new behaviors directed towards that object are not initiation acts. To qualify as an initiation act, the person initiating the act (initiator) and the target of the act must be attending to different things. The attempt of the initiator to direct the attention of the target and attend to the same object is the initiation act. Examples of initiation acts include saying something (i.e., Look at this kitty!) or making a noise (i.e., a gasp) to direct the target's attention, pointing to the book or moving it into the target's line of sight, or tapping on the target's shoulder to get their attention.

Successful Establishment of Joint Attention

Our two main criteria for characterizing the response to a bid are the type and duration of the response. To this end, we employ three different rules of engagement (Figure 2). The first is as follows. Once the initiator has finished the initiation act, the target has a three-second window of time in which to respond. There are various actions the target can perform that we consider indicative of a successful, engaged response. The non-initiating, or target, member can respond to a bid by pointing, gaze following, tapping, or touching the initiator, engaging with the object of mutual interest, deliberately gesturing within the initiator's visual field, changing affective demeanor, and/or producing language. The application of the three-second rule requires that the target engage in one or several of the above responses for at least one second within three seconds.

Joint attention was considered successfully established when an initiation act was followed by two on-topic, time-bound, contingent, back and forth communicative acts between the parent and child. Specifically, for joint attention to be established, the following sequences of events must take place:

(1) The initiator performed an initiation act as defined above.
(2) Within 3 seconds of the initiation act, the target responds by performing an on-topic verbal or non-verbal communicative act that lasted a minimum of 1 second.
    i. Examples of an on-topic response include looking at the shared focus of attention or saying something that acknowledges the shared focus of attention (e.g., "Yes, I see the kitty").
(3) Within 3 seconds of the target's response described in (2), the initiator performs an on-topic verbal or non-verbal communicative act that lasts a minimum of 1 second (i.e., "What do think the kitty's name is?").

Notably, these steps can all overlap with each other. For instance, the target could respond verbally (i.e., "A kitty?"; step 2) and during that response the initiator could point to the image (step 3). The actions in each step do not have to *last* 3 seconds, but each step must occur within 3 seconds of the previous step.

Failure to Establish Joint Attention

Additionally, we coded and quantified initiation acts that did not result in joint attention. In an effort to differentiate and compare successful versus failed attempts to establish joint attention, the proposed coding scheme (Figure 4) provides the option to include codes for failed bids. Here, a failed bid is any intentional bid that does not result in successful engagement on the part of the target. Using the three-second response window, we can identify successful bids, as described above, as well as failed bids. When a target fails to attend/integrate with the dyadic partner within the three second window, this qualifies the initiator's bid as unsuccessful. For example, a parent may use gaze as a bid to initiate joint attention with a child. Often a parent will follow such a bid with labeling. However, if the child is preoccupied directing their gaze in another direction or engaging with a different object, the child may miss this visual bid. Likewise, a parent may be consistent in cue timing, but the cues themselves may not work to guide the child's attention. If a parent is insensitive to this fact, the opportunity will be missed for the parent to adapt bid strategies and thus accommodate a child's specific sensitivities. Attempts to establish joint attention can fail at two points during the interaction:

(1) The target of the initiation act does not respond within 3 seconds (Figure 2).
(2) The target responds, but the initiator does not follow up by performing an on-topic communicative act.

Sensory Modality Coding

We were also interested in the type of sensory information used by the initiator when attempting to establish joint attention, regardless of whether this attempt was successful. Specifically, some cues and combinations of cues may be more effective than others in general, or when used by a specific initiator (parent vs. child). By coding and quantifying an initiator's use of multimodal cues, we can further inform a social account of joint attention and move away from a strictly visual interpretation and mechanism. Deák and colleagues (Deák et al., 2017) employed a microcoding scheme to investigate how parent-initiated joint attention is supported by gaze and manual actions. Most notably, the researchers found development of joint attention in parent-child dyads is the result of a co-modulation of behaviors between members of the dyad across months' worth of interactions. From this, the researchers argued that joint attention is complex, interactive, and is supported by the maturation of the child's sensorimotor networks, which affords engagement in multimodal communication. Initiators could either use one modality (unimodal codes) or a combination of modalities (multimodal codes) to establish joint attention. Each code is described in detail below.

1. *Unimodal codes*: there are two different auditory codes here. One is specific to noises made by a person, and the other focuses on noises made by objects in the environment.
    - **Auditory (Vocalization)**: the initiator makes a sound to gain the target's attention. This includes language, humming, other vocal sounds (e.g., "psst!"),
    - **Auditory (Non-vocalization):** the initiator acts on an object (e.g., book) to create an attention-getting noise. This can include tapping loudly on the book, or any other non-vocalized sound.
    - **Visual**: the initiator moves a hand or an object into the target's visual field to get the target's attention. This includes behaviors such as

waving, gesturing, reaching, pointing, offering the book, or holding an object in the target's visual field.

- **Tactile:** the interaction is initiated via touch, direct or indirect. This includes tapping or touching the child, touching with the book or a page of the book, or physically moving the child to direct their attention.
    - **Example:** Parents or children sometimes turn the page back or forward. If the page touches the target during the initiation act, this is considered tactile.

2. *Multimodal Codes*: For each combination involving an auditory code, there are separate options for vocalizations and non-vocalizations.
    - **Auditory – Visual:** the initiator uses both an auditory (vocalization or non-vocalization) and a visual behavior to gain the target's attention. This includes, but is not limited to, gesturing while talking, pointing to the book while describing it, or changing their facial expression while producing a vocalization.
    - **Auditory – Tactile:** the initiation uses both an auditory and a tactile cue. This includes touching the child with the book or a page of the book while describing it or making the accompanying noise.
    - **Visual – Tactile:** the initiator uses both a visual and tactile cue. This includes directing the child's attention to the book or an aspect of the book that is not currently within the visual field by physically moving the child (e.g., while the child was sitting in the parent's lap, the parent turns the child to guide him or her to look at new toys).
    - **Auditory – Visual – Tactile:** The initiator uses sounds, visual information, and touch in an effort to gain the target's attention (e.g., the parent showed the child the book, while labeling the labeling, and putting the book in the child's lap).

Results

To follow up on the previous studies which have implemented this coding scheme, we were interested in how certain features of the play session predicted engagement in joint attention. Planned analyses aimed to investigate individual differences in joint attention initiation by dyad. Following the planned analyses for differences between parents and children as the initiator, we used an exploratory approach to understand how parents and children engaged in joint attention at this age while interacting with a picture book. Preliminary analyses revealed no significant relationships between sex, age, income, education, children's language scores and the total number of bids nor bid outcomes for either parents or children, all ps > 0.106. Thus, we collapsed across these factors in the following analyses.

Comparing Parents and Children

The first set of analyses focused on describing how joint attention occurred between preschool-aged children and their parents. Specifically, we were interested in understanding which member of the dyad, parent or child, is shouldering the engagement in joint attention at this age. A paired samples t-test was conducted to compare the total number of initiation acts by the parent and the child. Parents produced significantly more bids for joint attention (*M* = 20.11, *SD* = 8.69) compared to children (*M* = 6.53, *SD* = 4.33), $t(18) = 7.78$, $p < 0.001$. This suggests that parents are still the main source of initiation acts when engaging with preschool-aged children during storybook reading.

We then calculated the proportions for each bid outcome relative to the number of total bids to examine whether the three potential outcomes (Successful, No Engagement, No Checking) of initiation acts varied across the initiating dyad members. Overall, parents produced significantly more successful bids (*M* = 16.68, *S*D = 7.71) than children (*M* = 4.79, *SD* = 3.16), $z = 2.35$, $p = 0.02$. However, parents and children were equally likely to initiate a bid for joint attention that resulted in No Engagement from the other dyad member ($M_{parents} = 2.42$, $SD_{parents} = 3.17$; $M_{children} = 1.21$, $SD_{children} = 1.75$), $z = -1.83$, $p = 0.07$, and bids where the initiating member did not check for engagement of the other, or 'No Checking' ($M_{parents} = 1.00$, $SD_{parents} = 2.06$; $M_{children} = 0.58$, $SD_{children} = 1.07$), $z = 1.29$, $p = 0.20$.

Lastly, we used paired samples t-tests to compare the number of times parents and children used either unimodal or multimodal sensory cues in their initiation acts. Parents used significantly more unimodal cues throughout the interaction (*M* = 8.89, *SD* = 5.68) compared to children (*M* = 3.00, *SD* = 2.36), $z = -0.34$, $p < 0.001$. Parents also used significantly more multimodal cues in the initiation acts (*M* = 10.79, *SD* = 9.28) than children did (*M* = 3.47, *SD* = 3.81), $t(18) = 4.13$, $p = 0.001$. Overall, parents were more likely to use both unimodal and multimodal cues when attempting to initiate joint attention compared to children, though this is due to parents' increased willingness to initiate joint attention in comparison. When we compared the proportions of bids performed by each of the initiating members for each modality type relative to the total number, we found no significant differences, $z = +/- 0.34$, $p = 0.74$.

Modality Use and Bid Outcomes

To follow, we completed partial correlations on the relationship between the outcome of the initiation act (successful/failed) and the parent's use of sensory modalities, controlling for the total number of bids initiated by the parent. Due to our small sample size and the use of correlations, we do not make any claims regarding the predictiveness of the cues. To account for the fact that parents who bid more had more overall opportunities for successful and failed instances of joint attention, we controlled for total number of bids by the initiating member in the following analyses.

What Coincides with Successful Parent Initiation Acts?

We first aimed to understand how parents were using sensory modalities to initiate joint attention. All bids were characterized as unimodal (the presence of just 1 sensory modality) or multimodal (incorporating 2 or more modalities). The parents' overall use of unimodal or multimodal bids had no correlation with any of the bid outcomes (see Table 3).

To explore the use of sensory modalities and their implications further, we completed partial correlations (controlling for total bids) to assess the relationship between each unique combination of sensory cues and the total number of successful initiation acts. We found significant negative relationships for the total number of successful parent initiation acts and the number of Auditory (Nonvocalization) cues and Auditory

(Vocalizations)–Visual–Tactile cues (Table 3). As parents' use of these sensory cues increased, their total number of successful bids decreased. In other words, parents that had opted not to use these types of sensory cues had more instances of successful bids for joint attention.

What Coincides with Failed Parent Initiation Acts?

We also examined the relationship between parental modality use and the total number of failed bids, both No Engagement and No Checking, controlling for the total number of bids. Here we identified a negatively trending relationship between No Engagement (on the part of the child) and Auditory (Nonvocalization)–Auditory (Vocalization) cues (Table 4). As parents increased the use of Auditory (Nonvocalization)–Auditory (Vocalization) cues, they had fewer instances of No Engagement. Thus, the parental use of multiple auditory cues (vocalizations and non-vocalizations) was related to an increase in the total number of bids resulting child engagement.

The outcome of No Checking (on the part of the parent) was significantly positively related to parental use of Auditory (Nonvocalization)–Auditory (Vocalization)–Visual cues and Auditory (Vocalizations)–Visual–Tactile cues (Table 5). There was also a trending positive relationship between No Checking and the use of Auditory (Nonvocalization) cues and the use of a multimodal Auditory(Nonvocalization)–Visual cues. Overall, as parents increased the incorporation of the above cues, the total number of bids that resulted in the parent not checking for engagement also increased. Additionally, there is a marginal negative correlation between Auditory (Vocalization) – Tactile cues and No Checking meaning that parents who used this cue more also had fewer instances where they did not check for child engagement

What Coincides with Successful Child Initiation Acts?

In contrast with our previous work, we coded and analyzed child-initiated bids for joint attention during this picture book interaction. Again, we aimed to understand how children were using sensory modalities to initiate joint attention. All bids were characterized as unimodal (the presence of 1 sensory modality) or multimodal (incorporating 2 or more modalities). We completed partial correlations, controlling for the total number of child initiation acts, to assess the relationship between the number of sensory modalities used and the total number of each outcome type. Additionally, neither unimodal nor multimodal bids were correlated with success (Table 3).

We further explored the use of sensory modalities and their implications using partial correlations (controlling for total child initiation acts) to assess the relationship between each unique combination of sensory cues the total number of successful initiation acts by the child. Successful bids for joint attention were significantly positively associated with unimodal Auditory (Vocalizations) (Table 3). When children were attempting to initiate joint attention with the parent, children who more frequently employed an Auditory (Vocalization) also had more instances of successful engagement. However, Auditory (Nonvocalizations) and Visual cues had significant negative relationships with successful bids for joint attention. Children who relied more heavily on Auditory (Nonvocalizations) and Visual cues had few instances of successful initiation acts.

What Coincides with Failed Child Initiation Acts?

We also examined the relationship between the total number of child initiation acts that resulted in failure to elicit joint attention and the child's modality use when controlling for the total number of child bids. Here, we found that Auditory (Nonvocalizations), and Auditory (Vocalization)–Tactile cues were all related to an increased number of failed bids for joint attention due to No Engagement on the part of the parent (Table 4). On the other hand, Auditory (Vocalizations) were negatively correlated with No Engagement, meaning that as children's use of this cue increased, the parent was more likely to engage. Relatedly, as children increased their use of Auditory(Vocalization)–Visual cues, they also exhibited fewer instances of checking for parent engagement. However, as children incorporated more Visual cues, the total number of bids that resulted in No Checking (on the part of the child) also increased (Table 5). Children who incorporated more multimodal cues into their interactions also had an increased number of bids that resulted in No Checking (on the part of the child), while children who used more unimodal cues had fewer instances of No Checking – a finding we return to in the discussion.

Interaction-Specific Factors and Bid Outcomes

In Chapter 3, we found a relationship between the total length of parent utterances and the total number of successful bids. Specifically, that parents who used longer utterances exhibited more instances of successful engagement of joint attention regardless of the child's hearing status. In the current study, we have measures of duration of the picture book activity, as well as the total number of parent utterances used during the activity. Interestingly, we found no correlation between the total amount of time parents and children spent with the book and the total number of bids nor any specific bid outcomes, all *p*s > 0.121. However, when we controlled for the duration of the task, we found a trending relationship between the total number of parent utterances and the total number of successful parent initiation acts, $r = .487$, $p = .056$.

Discussion

Overall, we found several relationships between what parents and children do in these interactions and how often they succeed or fail to engage in joint attention. The main findings were as follows:

1. Parents were still the main source of initiation acts at this age during picture book reading. Parents were also more successful in their initiation acts compared to children, who were less likely to make a bid for the parent's attention and less likely to succeed in initiating when they did bid.

2. None of the demographic variables that we measured were significantly related to the parent or child's total attempts to initiate joint attention or the total number of times either member succeeded or failed.

3. Parents had fewer successful initiation acts when they used more Auditory (Nonvocalization) cues alone or the multimodal Auditory (Vocalization) – Visual – Tactile cue in their bids for joint attention. On the other hand, the more often parents used Auditory (Vocalization) –Visual – Tactile cues, they had significantly fewer bids that resulted in the child not engaging and significantly more bids that resulted in the parent not checking for the engagement of the child.

4. Children had more total successful initiation acts when they used more Auditory (Vocalization) bids, as opposed to Auditory (Nonvocalization) cues and Visual

cues, which both were related to fewer total successful bids. However, children who used more Auditory (Nonvocalizations) also had more bids that resulted in no engagement from the parent. Also, the more often children used a unimodal visual cue or multimodal cues overall, they had significantly more bids in which they did not check for the adult's engagement.

In discussing the findings, there are some limitations that must be kept in mind. These data were not originally collected to analyze joint attention; thus, the task and the procedure were not tailored for this purpose. Due to this, several dyads had to be excluded, so our sample size is relatively small. Importantly, due to the correlational nature of the data and the analyses, we do not make causal inferences.

Finding 1, that parents are more frequent and better initiators of joint attention at this age during this type of task, was not particularly surprising. Because the method and specific investigations of this study are exploratory, we did not have any particular predictions regarding which dyad member would or would not be more willing and able to direct the attention of the other. While the aim of this study was to observe and describe how parents and children engage in joint attention at this age, the contrived nature of the observation may not reflect typical behavior. Other research on comparing the context of parent-child interactions suggests that when parents and children interact in a distraction free, laboratory setting (like ours) ratings of interaction quality are consistently higher (O'Brien et al., 1989), perhaps because parents are sensitive to being observed. Parents may feel the need to "perform" during this task, and thus disproportionately initiate joint attention with their child, leaving the child with fewer chances for initiating themselves. Indeed, we interpret this finding with caution and encourage the exploration of this question in a more naturalistic environment with familiar stimuli.

Individual Differences

While we originally expected that some demographic factors would relate to individual differences in joint attention engagement, the lack of this finding is not unique. Finding 2, the lack of individual differences, is actually in line with several studies that report on infant-parent interactions. For example, Gaffan and colleagues (2010), examined joint attention behaviors between infants and their parents longitudinally from 2-9 months. Overall, they aimed to explain individual differences in engagement at nine months. However, researchers found that there was no association between engagement in joint attention and gender, socioeconomic status, or the child's ability to pass an object permanence task. Although we are not alone in the inability to identify individual differences, this lack of significant relationships is interesting given the differences reported in older (7+) children by Bean and Eigsti (2012). Specifically, Bean and Eigsti used a novel, experimental assessment for responding to joint attention engagement in typically developing 7-17-year-olds. The child's responses to 6 prompts were scored based on the quality of the social response, where higher scores were more social. Overall, they found that typically developing children received highly variable scores between 14-22, where 24 is a perfect score. However, researchers did not attempt to uncover what factors could have influenced these differences. It is important to note that the age of the children in the current study falls in between those of the previously mentioned studies. Because our task was not originally intended to assess for joint attention, the lack of associations could be task-related. Children at this age may exhibit more pronounced individual differences in a free play task, as opposed to a book reading task. Additionally, the current study focuses on concurrent measures of demographics, engagement in joint attention and performance on social cognition tasks. Are these relationships associated or predictive across time, as opposed to concurrent? This is an open question.

Previous research has identified several factors that theoretically should or could influence children's engagement in joint attention. Parents from different socioeconomic backgrounds have demonstrated differing amounts of quantity and quality related to speech input and book reading. Specifically, differences in frequency of overall maternal talk (Whitehurst et al., 1994) and unprompted discussions during reading interactions (Payne et al., 1994) have both been shown to vary by socioeconomic status and produce variable language outcomes for the child. While we did not identify differences based on the family's socioeconomic status, this relationship could provide some insight into individual differences, perhaps through a mediation model. Lastly, there is some evidence to support the idea that the participating parent may affect the engagement in joint attention. For example, children may be more inclined to respond to bids when interacting with mom but initiate more bids when interacting with dad (Martins et al., 2014).

In the current study, we used a methodology that identifies how well the dyads are performing in terms of success or failure, which allows for unique insight into when and how these individual differences may influence the quality of these interactions, rather than just inform whether or not they are happening. Understanding the individual differences in the engagement of joint attention can further our understanding of the theoretical underpinnings and emergence of attention sharing more broadly, as well as inform the relationship between attention sharing and later social cognition. If there are, in fact, between-dyad differences in the engagement in joint attention, what types of demographic, interaction-based, and socio-cognitive factors are contributing to these differences? Future research should continue to explore the potential causes and outcomes related to individual differences in joint attention initiation and responding across various age groups.

Parent Initiation Acts

We identified a variety of modality-specific actions that affected parents' ability to effectively engage in joint attention with their preschool-aged child. The discussion here largely centers around modalities that were significant across bid outcomes, and what that means for the overall engagement in joint attention. Auditory (Vocalization) – Visual – Tactile cues were significantly negatively related to the total number parental successes and no engagement on the part of the child. This means that the use of this cue in particular was related to fewer bids for joint attention that resulted in success and fewer bids in which the children did not engage. However, parents who used a higher number of Auditory (Vocalization) – Visual –Tactile cues also had more instances in which they did not check for the engagement of the child. Here, successful joint attention required that the initiator check for the engagement of the target. However, this criterion was selected based on joint attentional engagement with younger children (9-24 months). Parents of children this age may already have a consolidated routine for joint attention and thus know that when they incorporate this combination of sensory cues that the child is going to engage. Worth pointing out is that just any set of multimodal cues does not elicit this No Checking response; it is specific to Auditory (Vocalization) – Visual –Tactile cues and Auditory

(Nonvocalization) – Auditory(Vocalization) – Visual cues. One way to assess this relationship in future research is to compare the total number of successful bids using the current coding protocol with the total number of successful bids in which parents need not actively check for the engagement of the child.

In addition to these cues, parents who used more Auditory (Nonvocalization) cues had significantly fewer successful initiation acts and more instances in which they did not check for child engagement. This finding is in contrast to what has been observed in our previous work with 13-month-old children and their parents, where we found that a bid containing a non-vocalized auditory cue was more likely to result in successful joint attention than bids without this cue (Gabouer et al., in prep). Because there is not a significant relationship between Auditory (Nonvocalization) cues and No Engagement, it may be possible again that this type of cue does not necessarily require a parent to check for the child's engagement. Perhaps the novelty of the noises that certain objects make serves to elicit a more engaged response from children at this age than any sounds the parent can make, and parents are aware of this. After all, a hearing child presumably hears parent vocalizations throughout the day. By this age children are accustomed to the parent's voice referring to whatever is being attended to (West & Iverson, 2017). According to this view, it is only when the parent acts on an unfamiliar object, such as a toy, to create a new noise, that this unknown. This novel sound captures the child's attention in a way parentally produced vocalizations—whether sounds or words—do not. Clearly, much research is needed to determine the roles that different types of cues play in establishing joint attention.

While we found no significant relationships between the parent's use of Auditory (Vocalization) cues and any of the bid outcomes (success or failure), there was a trending relationship between the total amount of parental utterances produced during the interaction and the total number of successful initiation acts by the parent. How is it that parents who speak more have more successes, but there is no relationship between the total Auditory (Vocalization) cues used to initiate joint attention? One potential reason behind these opposing outcomes is that Auditory (Vocalization) cues are not significantly related to successful *initiation* of joint attention, but rather support the *maintenance* of joint attention between parents and children. Parents who are vocalizing more *after* they have initiated joint attention would have higher amounts of utterances that are not necessarily correlated with whether a specific initiation was successful or not. However, because vocalizations are used for maintenance, as opposed to initiation, children who are familiar with this routine could be more likely to respond to parent initiation acts when the parent employs other types of sensory information. In other words, if parents are relying on anything but Auditory (Vocalization) cues to initiate joint attention with their child, the child may pick up on this and be more likely to successfully engage when the parent uses cues that do not incorporate a vocalization. Future research can use the protocol outlined here as a means to assess the differences in parent vocalizations during instances of initiation versus maintenance of joint attention.

Child Initiation Acts

In contrast to our previous research with this coding scheme, and much of the research on parent-child interactions more broadly, we coded and analyzed child-initiated bids for joint attention, as well. While we found that children initiate significantly less than parents, children did employ a variety of cues in an effort to direct their parent's attention.

For instance, children with higher numbers of unimodal Auditory (Vocalization) cues also had more Successful bids and fewer bids that resulted in No Engagement from the parent. At this age, children may rely more on auditory vocalizations because they find them to be more effective, given the overall higher amount of parent engagement when they use these cues. This finding is the opposite of what works for parents when they bid for their child's attention. Overall, parents' use of Auditory (Vocalization) cues, at least in conjunction with other sensory cues, is most commonly related to a failure of the initiation act.

It seems that, during this task at least, children are commonly attempting to initiate joint attention through the use of unimodal cues – almost all of the cues that were significantly related to any type of bid outcome were unimodal (in addition to 2 multimodal cues). However, unimodal cues were not always the most successful. Visual cues and Auditory (Nonvocalization) cues on their own were related to fewer instances of Successful child-initiated joint attention. We also found that children who used more unimodal cues and fewer multimodal cues had more bids that resulted in the child No Checking for adult engagement. This finding suggests that children are potentially more comfortable bidding for their parents' attention by using a unimodal cue, and therefore do not check that the parent is engaged when they employ such cues. Relatedly, children who had more unimodal Visual bids also had more bids in which they did Not Check for the adult's engagement. Perhaps this is, again, the result of a well-established routine between the parent and child, such that when the child bids unimodally, specifically in the Visual modality, they were historically more likely to succeed and no longer continue to check for adult engagement before proceeding with the interaction. Because this cue is specifically related to lower instances of Success and higher rates of No Checking, it may not be the case that the child is assuming the cue will be successful. It may also be the result of a visual fixation to a novel referent (Colombo et al., 1991), meaning that children are slower to process these images or that they are so encapsulated by them that they do not break gaze to check for the parent's attention.

Conclusions

The current study provides an initial pass to explore the various sensory cues parents and children have in their arsenal and their relationship with successful and failed bids for joint attention. Because our findings are correlational, it is difficult to interpret these relationships within the greater context of joint attention research. Importantly, this study informs a more wholistic description on typical engagement in joint attention and also demonstrates the application of our coding protocol to this method of assessment. Our results also contribute to the growing literature on the implications of multimodal cueing in joint attentional engagement. Specifically, we found that parents of children this age are continuing to incorporate a variety of unimodal and multimodal cues as they bid for their child's attention. We also supplement these findings on parent-initiated joint attention with a closer look at child-initiated joint attention at an age that is not commonly captured in joint attention research.

Here, we found that parents still play a leading role in initiating joint attention at this age. We also identified several unimodal and multimodal cues that parents and children use to initiate joint attention and how they relate to the outcomes of the initiation acts. Our findings also contribute to a clearer, more accurate picture of how children beyond the age of 36 months initiate joint attention – vocally. This aligns with our original prediction that children may have a large enough vocabulary and ample prior experience of engaging in joint attention with their parent that a simple Auditory (Vocalization) is enough. Contrary to our predictions, we did not find any significant relationship between the parents' use of multimodal cues and the number of successful bids for joint attention. While parents did use more multimodal cues compared to children, the lack of correlation with success suggests that less is more, at least during a picture book task. Qualitative results such as ours showcase the messiness of parent-child engagement in joint attention, but also the utility of our protocol to assess a developmentally diverse populations in a variety of tasks.

Chapter 5

Overall, this research aims to better describe and categorize the way parent-child dyads engage in joint attention. With two unique groups we a) relied on atypical development to inform a better understanding of the typical emergence of joint attention to provide a fuller picture regarding how parents, and children, work to engage each other about the environment, and b) provide an initial investigation into joint attention as children enter formal schooling. Taken together, the findings here inform not only the ways parents and children can effectively share attention to produce a learning experience, but how parents can scaffold these interactions and effectively repair failed attempts to engage in joint attention. Specifically, we highlight the unique aspects of social engagement that help to reconfigure a dyad's successful response to and initiation of joint attention.

Chapter 2 introduces a novel coding protocol, prompted by the work presented in Chapter 3, which aims to better capture the sensory qualities parents and children rely on during social exchanges in the attempt at directing the attention of the other. Overall, the word 'joint attention' has grown to encompass several facets of the interaction. The coding protocol focuses on how joint attention is *initiated*, rather than *maintained*. The initiation of joint attention encompasses the short period of time (~3-6 seconds) during which a parent makes an intentional attempt to direct a child's attention. In contrast, the maintenance of joint attention describes the episode that follows the initiation period. For example, a parent and child can be playing with puppets when the parent spots a novel rattle toy with which to engage the child. To initiate joint attention, the parent reaches for the rattle and shakes it in the child's visual field. The child engages, and the two begin interacting with the rattle. The point at which the child engages marks the end of the initiation period and the beginning of attentional maintenance. In other words, any continued interaction between the parent and child regarding the rattle following the parent's initial effort to engage the child (i.e., singing a song using the rattle to keep the beat) would be considered maintenance of joint attention on the part of the parent. The current study focuses exclusively on how parents attempt to enter the state of joint attention.

The reason for carefully differentiating initiation from maintenance is because they involve fundamentally different states in the child, yet have been lumped together in the literature, referred to as simply as "joint attention." Our coding protocol (Gabouer & Bortfeld, 2021) has produced findings (i.e., Gabouer et al., 2020) that are more nuanced from other multimodal joint attention research (e.g., Depowski et al., 2015; Suarez-Rivera et al., 2019). While those studies suggest that multimodal cues produce longer bouts of shared attention, we also found that multimodal cues are more effective at initiating joint attention with toddlers in a free play paradigm (Gabouer et al., in prep).

Although this is not a conventional tool for measuring joint attention, we (Gabouer et al., 2020) and others (Botero, 2016; Siposova & Carpenter, 2019) have argued that this is a more accurate operationalization of the construct of interest. Most importantly, the protocol allows for the classification of all parental bids for joint attention, whether successful or failed – an approach that is maximally informative about the mechanisms underlying the establishment of joint attention. By characterizing the behaviors underlying both successful and failed bids for joint attention, we can better understand the dynamics

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at play for parents during the establishment of joint attention with their young children, and vice-versa.

Chapter 3 originally questioned how hearing parents accommodate their deaf child as they bid for their attention. In the process, we uncovered that hearing parents of deaf children weren't all that different from hearing parents of hearing children. More specifically, in comparing hearing parent-deaf child dyads to hearing parent-hearing child dyads, we found no differences between overall attempts to establish joint attention, nor in the modalities used in those attempts. Rather, hearing parents as a whole seem to default to interacting with their child via multiple modalities despite two factors. One factor being that hearing-hearing dyads can effectively operate solely within the auditory modality (as predicted), and the second being that although parents in hearing-deaf dyads know their child is deaf, they persist in producing auditory cues (albeit by including significantly shorter MLUs).

Recent work has argued that a bias in joint attention research towards the visual modality (Botero, 2016) ignores an important potential source of influence: the use of touch in parent-child interaction around the world and across species. Given the possibility of establishing joint attention via non-auditory means (Akhtar & Gernsbacher, 2008), there are clearly many ways in which meaningful communication does take place between parents and their children, regardless of either's hearing status. The observations reported here highlight the utility of moving beyond standardized (i.e., gaze-based) measures of joint attention to obtain rich, ecologically valid data on the details of parent-child interaction. Chapter 3 lends support for tracking the use of multisensory input by parents, particularly their use of audition and touch, during their interactions with children, as such input likely has long served in the establishment of communicative success. While the original investigation focused on how hearing parents accommodated their deaf child through other sensory modalities, we found that *all* dyads were employing several combinations of sensory cues to effectively elicit their child's attention, whether the child was hearing or deaf.

The findings presented in Chapter 3 are consistent with our earlier work that demonstrated a wide variability in the ways that hearing parents try to engage their hearing children in joint attention. Given that findings from the study indicate that hearing parents use the auditory modality quite a lot with their deaf children despite their have limited-to-no access to the auditory modality, further research is needed on the role of modality in the establishment of joint attention in hearing parent-deaf child dyads. Indeed, other work has found that hearing mothers tend to use the auditory modality to engage their children regardless of the child's hearing status (Koester & Lahti-Harper, 2010). If a deaf child does not experience the communicative modality being used (i.e. spoken language), the parent may very well be doing something else (i.e., in another modality) to engage that child's attention. Our own data demonstrated that parents of deaf children rarely use the auditory modality in isolation, instead opting to combine it with other modalities (i.e., visual, tactile) that are more accessible to their children.

Indeed, there is a growing body of research focusing on the adjustments that hearing mothers of deaf children make to accommodate their children's hearing status and findings from the present study add to that. These findings are also consistent with findings that, during free play sessions with their nine-, 12-, or 18-month-old infants, hearing mothers of deaf infants tended to move objects into the child's line of sight or touch/point to objects (i.e. use the tactile and visual modalities) more than mothers in the hearing parent/hearing child dyads (Waxman & Spencer, 1997). If this is the case, then one might expect to see similar, or perhaps even greater, levels of joint attention in those hearing parent-deaf child dyads in which parents use accommodating techniques to gain their deaf children's attention.

This was one of the initial revelations that parents who can rely solely on auditory cues are actually just as haptic as parents who cannot communicate with their children through verbal cues. However, the small number of children in this study (Gabouer et al., 2020) were also of varying ages and hearing statuses, ranging from normal to severely-impaired hearing. In Chapter 4, we used these findings to generate a novel question—how do parents and preschool-age children use one or more sensory cues to elicit joint attention during a picture book task? Based on previous research, it was unclear how these dyads will interact. However, previous research with our coding protocol (Gabouer et al., 2020; Gabouer et al., in prep) and others (de Barbaro et al., 2016; Heller & Rohlfing, 2017; Streeck et al., 2011) suggests that multimodal cues are both common and effective.

Chapter 4 aimed to expand on the investigation of how parents and children effectively engage in joint attention at this age, as well as potential sources of individual differences in the success or failure of bids based on the sensory modalities used by the initiator. Our findings provide important insights into joint attention between parents and their older children, specifically as they prepare to enter formal education. For example, we found that individual differences in a parent's overall number of utterances during a picture book task was related to successful engagement in joint attention. This study, though not originally intended for joint attentional coding, suggests that parent-child book reading presents fruitful answers to questions about the trajectory of joint attention throughout development and across tasks. Such qualitative knowledge can inform how school-age children interact with adults, highlighting how parents and teachers can tailor their interactions to increase successful engagement.

Future Directions

Our current protocol, informed by the social account, relies heavily on an intentional bid for joint attention by the initiating member. The intention and active verification (i.e., checking-back) components of joint attention are part of an ongoing debate as to how joint attention should be operationalized and how its instantiation should be measured (see Siposova & Carpenter, 2019 for suggestions). This purposeful initiation act is used to account for what parents and children are doing within their immediate control to successfully bid for joint attention. This is important to note, as we work with an eye toward informing public policy and educating parents and other caregivers on what works best to scaffold these interactions. Importantly, parents, caregivers, and children cannot directly alter their accidental initiations of joint attention. The question of, 'What leads to joint attention?" and "What happens before joint attention?" are fundamentally different. Leading another person into joint attention implies an effortful, internal desire to share, whereas happening upon joint attention emerges by accident. Even so, the current protocol can be modified to answer this question, as well as some of the others that are posed throughout this dissertation. For example, we can expand or remove the intentionality component of the initiation act to understand the difference between the two types of joint attention (incidental and intentional). This comparison can provide further clarity in terms of the geometric mechanism proposed by the associative account and how it could be used to engage in joint attention haphazardly.

Engagement in joint attention is not a one-size-fits-all process, it is a cluttered and complicated social dance. Overall, it seems that certain individual differences in joint attention predict socio-cognitive outcomes in the following months and years, but it is still an open question as to the specific mechanism that supports this relationship. Future research should continue to explore the relationship between joint attention and other mentalizing tasks to understand the mechanisms and processes that may overlap or differentiate in these types of reasoning tasks.

Conclusions

Taken together, these findings reveal important information about the degree to which parents incorporate multimodal cues when interacting with their children. Although documentation of (and appreciation for) the complexity of parent-child interactions has grown in recent years (e.g., Battich et al., 2020; Deák et al., 2017), these are the first studies to systematically examine the influence of different numbers of sensory cues on parents' ability to successfully engage their children in joint attention and to do so in a semi-natural setting. Traditional methods that document joint attention using one or another sensory cue (i.e., point- or gaze-following paradigms) unnecessarily discount additional sources of information that a child may use in allocating attention.

Our results demonstrate that extending the measurement of joint attention to include multimodal information can more accurately characterize the behaviors that support successful communication during parent-child interactions. Such adjustments will broaden our understanding of how parents engage their children, and better characterization of what parents do to effectively establish joint attention in interactions with their children has implications for word learning and social cognition, among other things. Documenting the use of different sensory cues, alone and in combination, is a critical first step toward incorporating them into experiments that can manipulate ability to engage in joint attention. Importantly, the form of micro-coding that we have introduced here provides a potential direction for researchers interested in developing therapeutic interventions for families who cannot communicate via a common sensory modality, as is the case for hearing parents of deaf children.

Lastly, the many iterations of our coding protocol have prompted us to include and analyze what does *not* work, compared to what does, when parents and children attempt to initiate joint attention. Knowing what does not work to engage a child in joint attention can help identify how parents, and practitioners, can help repairs these interactions in an effective manner. To our knowledge, these are the first papers to record and analyze failed bids for joint attention in the service of further understanding the effective initiation of joint attention. In adopting the methodology described above, we provide the resources to better understand not only what works, but what is not effective when attempting to engage children in joint attention during this crucial phase of social development. This methodology is contrast to eye-tracking methods which capture only the successful bouts of engagement; while important, a common and crucial piece of the interaction is missing.

Our approach to characterizing how parents establish joint attention with their children embraces the unique, multimodal aspects of naturally occurring parent-child engagement. In doing so, we have observed that parents do not engage their children in joint attention strictly via the auditory or visual modality; rather, they incorporate multiple modalities. In support of this approach, we have introduced a systematic coding protocol to identify instances in which a parent attempts to engage a child in an interaction centered around an object, allowing it to be classified as successful or failed while also providing a means to label each sensory modality or modalities there were used. Because our dyadic interactions took place in a semi-naturalistic/semi-structured setting, these finding provide important insight into how these interactions may unfold in the real world. Thus, the findings we report here serve as an important initial step towards understanding the complex ways parents work to establish joint attention with their children. Further research is certainly needed that includes detailed micro-coding of naturalistic parent-child interactions to document how parents incorporate multiple modalities in their effort to establish joint attention with children. This collection of findings underscores the multimodal nature of parent-infant interactions, contributing to our understanding of the myriad ways parents achieve joint attention with their children.

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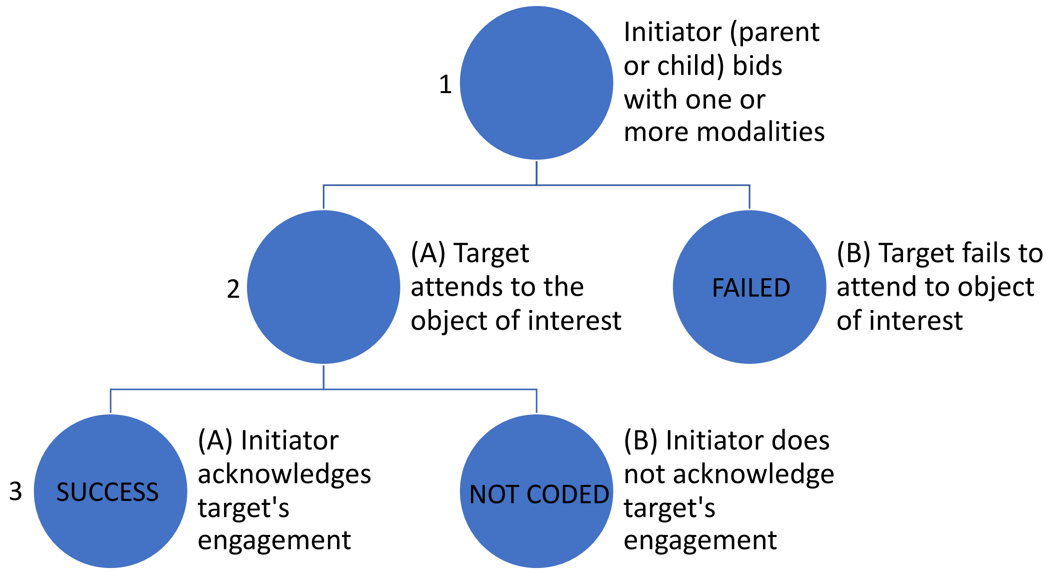
Tables and Figures

Figure 1

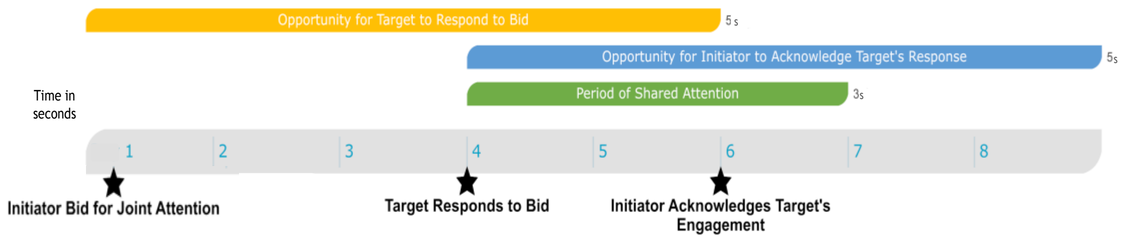
Decision tree for identifying joint attention in Chapter 2



Note: Step one reflects the criteria described in Chapter 2's Intention section. If the bid is determined to be intentional, the second level refers to the non-initiator's response to step one (see Chapter 2). Lastly, the third level represents verification by the initiator (described in Chapter 2, Active Verification). Each level of the decision tree requires a yes or no decision that either ends the identification process and provides the appropriate label for such a situation or meets the criteria for a successful initiation of joint attention.

Figure 2

Chapter 2. Timeline of the initiation of joint attention initiation in seconds



Note: Seconds 0-5 indicate the time after the initial bid for joint attention (1). After the onset of a bid, the non-initiator needs to respond to the bid within 5 seconds (yellow bar) for the bid to be considered a success (2). If the target does not respond, it is classified as a failed bid (Figure 1: 2B). Once the target responds, the pair must engage with the object of mutual interest for at least 3 seconds (green bar). During this time, the initiator has a 5 second period to acknowledge the target's response (blue bar). If the initiator fails to acknowledge the engagement of the target, the bid is not coded (Figure 1: 3B). Note: these times can be adjusted based on the specific population of interest, as can the requirement for initiators to verify joint attention (the final step).

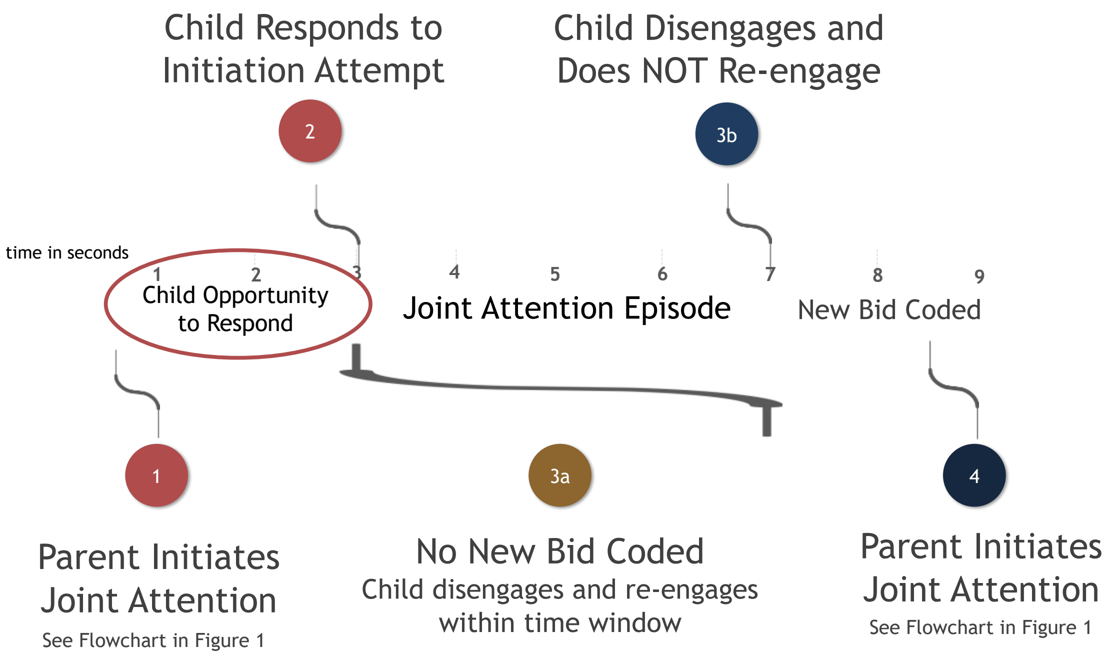
Table 1

Chapter 3. Demographic information of sample (Study 1A and B)

	Hearing-Deaf Dyads	Hearing-Hearing Dyads	% Total
White	2	8	56%
White-Hispanic	6	1	39%
Asian	1	0	5.6%
Totals	9	9	100%

Figure 3

Chapter 3. Timeline of the initiation and offset of joint attention in seconds



Note: Seconds 0–3 indicate the time after the parent made an initial bid for joint attention (1). After the onset of a bid, children needed to respond in 3 seconds to the bid for it to be classified as a successful bid. If the child did not respond, it was classified as a failed bid. During this 3-second window, any modality cues used by the parents were coded up until the point at which the child responded or if they did not respond at the end of the 3-second window (2).

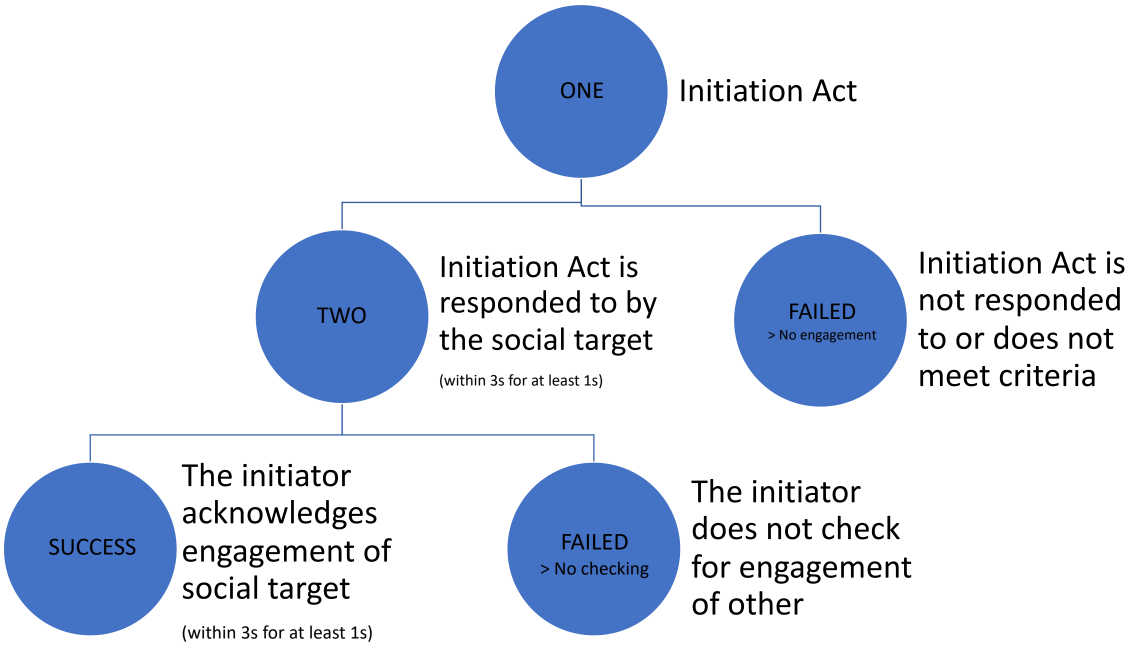
Table 2

Chapter 3. Raw Frequency of Occurrence for Each Modality by Joint Attention Bid Type and Dyad Hearing Status

Modality	Auditory		Visual		Tactile		Auditory-Visual		Auditory-Tactile		Visual-Tactile		Auditory-Visual-Tactile	
Hearing Status	HH	HD	HH	HD	HH	HD	HH	HD	HH	HD	HH	HD	HH	HD
Bid Type														
Successful	9	3	7	8	0	0	28	23	1	0	0	1	2	4
Failed	2	3	4	2	0	0	10	12	0	0	0	0	0	4

Figure 4

Revised coding tree used to identify successful and failed joint attention in Chapter 4



Note: Step one reflects the criteria described in Chapter 2's Intention section. If the bid is determined to be intentional, the second level refers to the non-initiator's, or target's, response to step one. This step either results in a successful, engaged response within the allotted time, or fails to engage the target member and thus is coded as Failed – No Engagement. Lastly, the third level represents verification by the initiator (described in Chapter 2, Active Verification). A successful acknowledgment completed by the initiator results in a code of Success, whereas failure to check for engagement (on the part of the initiator) is coded as Failed – No Checking. Each level of the decision tree requires a yes or no decision that either ends the identification process and provides the appropriate label for such a situation or meets the criteria for a successful initiation of joint attention.

Figure 5

Sample setup for the picture book task in Chapter 4

Table 3

Chapter 4. Partial Correlations Between Cue Type and Successful Initiation of Joint Attention Controlling for Total Bids, Separately for Parents and Children

	Parent	Child
Modality Type		
Unimodal Cues	.38	-.22
Multimodal Cues	-.38	.22
Auditory (Vocalization)	.32	.62**
Auditory (NonVocalization)	-.50*	-.79***
Visual	.23	-.63**
Tactile	.23	.15
Auditory (Vocalization)-Auditory (NonVocalization)	.31	-
Auditory (Vocalization)-Visual	-.34	.30
Auditory (Vocalization)-Tactile	.18	-.18
Auditory (NonVocalization)-Visual	-.09	-
Auditory (NonVocalization)-Tactile	-	-
Visual-Tactile	.03	.04
Auditory (Vocalization)-Auditory (NonVocalization)-Visual	-.17	-
Auditory (Vocalization)-Auditory (NonVocalization)-Tactile	-	-
Auditory (Vocalization)-Visual-Tactile	-.54*	-.09
Auditory (NonVocalization)-Visual-Tactile	-	-
Auditory (Vocalization)-Auditory (NonVocalization)-Visual-Tactile	-	-

Note: $N = 19$ †$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$; - not observed

Table 4

Chapter 4. Partial Correlations Between Cue Type and Number Bids for Joint Attention Resulting in No Engagement Controlling for Total Bids, Separately for Parents and Children

	Parent	Child
Modality Type		
Unimodal Cues	-.17	-.35
Multimodal Cues	.17	.35
Auditory (Vocalization)	-.10	-.55*
Auditory (NonVocalization)	.21	.62**
Visual	-.16	.01
Tactile	-.12	-.02
Auditory (Vocalization)-Auditory (NonVocalization)	-.44†	-
Auditory (Vocalization)-Visual	.20	.21
Auditory (Vocalization)-Tactile	.12	.47*
Auditory (NonVocalization)-Visual	-.22	-
Auditory (NonVocalization)-Tactile	-	-
Visual-Tactile	.03	.07
Auditory (Vocalization)-Auditory (NonVocalization)-Visual	-.17	-
Auditory (Vocalization)-Auditory (NonVocalization)-Tactile	-	-
Auditory (Vocalization)-Visual-Tactile	-.54*	.39
Auditory (NonVocalization)-Visual-Tactile	-	-
Auditory (Vocalization)-Auditory (NonVocalization)-Visual-Tactile	-	-

Note: N = 19; †p < .10; *p < .05; **p < .01; ***p < .001; - not observed

Table 5

Chapter 4. Partial Correlations Between Cue Type and Number Bids for Joint Attention Resulting in No Checking Controlling for Total Bids, Separately for Parents and Children

	Parent	Child
Modality Type		
Unimodal Cues	-.32	.61**
Multimodal Cues	.32	-.61**
Auditory (Vocalization)	-.33	-.22
Auditory (NonVocalization)	.44†	.34
Visual	-.12	.77***
Tactile	-.17	-.16
Auditory (Vocalization)-Auditory (NonVocalization)	.16	-
Auditory (Vocalization)-Visual	.21	-.58*
Auditory (Vocalization)-Tactile	-.41†	-.25
Auditory (NonVocalization)-Visual	.41†	-
Auditory (NonVocalization)-Tactile	-	-
Visual-Tactile	-.12	-.13
Auditory (Vocalization)-Auditory (NonVocalization)-Visual	.47*	-
Auditory (Vocalization)-Auditory (NonVocalization)-Tactile	-	-
Auditory (Vocalization)-Visual-Tactile	.55*	-.28
Auditory (NonVocalization)-Visual-Tactile	-	-
Auditory (Vocalization)-Auditory (NonVocalization)-Visual-Tactile	-	-

Note: $N = 19$; †$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$; - not observed